55-1905-217-34

TECHNICAL MANUAL

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

LANDING CRAFT, MECHANIZED, STEEL, DED, OVERALL LENGTH 74 FEET, MOD 1, MARK VIII, NAVY DESIGN LCM-8 (GUNDERSON BROS. ENGINEERING CORP., MARINETTE MARINE CORP., AND ROHR CORP.) FSN 1905-935-6057

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WARNING

DANGEROUS CHEMICALS

are used in this equipment.
SERIOUS INJURY OR DEATH
may result if personnel fail to observe these safety precautions.

Avoid contact with the battery electrolyte.
If the solution comes in contact with the skin, rinse the area immediately with clear water to avoid skin burns.
Be sure all cargo is secure, especially during rough seas.

WARNING

FIRE OR EXPLOSION HAZARD

SERIOUS INJURY OR DEATH

may result if personnel fail to observe these safety precautions.
Hatches must be open before energizing any electrical circuits or starting engines.
Do not smoke or use an open flame in the vicinity when servicing batteries as hydrogen gas, an explosive is generated. Use only distilled water to maintain battery electrolyte level.
Do not fill fuel tank while engine is running.
Provide metallic contact between the fuel container and fuel tank to prevent a static spark from igniting fuel.
Wipe or flush any spillage.
Volatile materials will not be brought aboard;
electrical circuits will not be energized;
fuel tanks will not be topped off;
and engines will not be started
before CO_2 fire fighting
equipment is available
and operative.

Observe NO SMOKING rules when refueling.
Do not work on live circuits. Tag circuit and warn other personnel not to energize the circuit.
Never use a blow torch or other similar means for heating fuel or oil lines.

WARNING

ASPHYXIATION DANGER

Be sure engine room ventilators are open when operating the engine(s).
The engine exhaust gases contain carbon monoxide which is a colorless, odorless, and poisonous gas.

URGENT

TM 55-1905-217-34
C 2

CHANGE NO. 2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 28 June 1984

Direct and General Support Maintenance Manual

LANDING CRAFT, MECHANIZED, STEEL, DED
OVERALL LENGTH 74 FEET, MOD 1, MARK VIII,
NAVY DESIGN LCM-8
(GUNDERSON BROS. ENGINEERING CORP,
MARINETTE MARINE CORPORATION,
AND ROHR CORPORATION)
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CHANGE NO. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *30 April 1979*

Direct Support And General Support Maintenance Manual

LANDING CRAFT, MECHANIZED, STEEL, DED OVERALL LENGTH 74 FEET, MOD 1, MARK VIII, NAVY DESIGN LCM-8 (GUNDERSON BROS. ENGINEERING CORP, MARINETTE MARINE CORPORATION, AND ROHR CORPORATION) NSN 1905-00-935-6057

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3-5 and 3-6	3-5 and 3-6
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3-63 thru 3-66	3-63 thru 3-66
3-147	3-147
4-25 and 4-26	4-25 and 4-26
4-81 and 4-82	4-81 and 4-82

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SERIOUS INJURY OR DEATH

may result if personnel fail to observe these safety precautions.
Avoid contact with the battery electrolyte.
If the solution comes in contact with the skin, rinse the area immediately with clear water to avoid skin burns.

Acids can cause serious burns or blindness. Avoid contact with eyes, skin, or clothing. Do not breathe vapors. Wear rubber gloves, goggles, and a rubber apron when handling them. When diluting acids, do not add water to acid; the acid must be added to the mixture slowly and with constant mixing. In case of contact with acid, flush the affected area with plenty of water and obtain medical aid immediately.

Before working on any electrical equipment, make sure the circuits has been deenergized and the cables have been disconnected from the battery.

When cutting with a torch, or when welding, always station fire watches, ready with fire extinguishers, in the vicinity on both sides of the plate that is being cut or welded.

Ramp hinge pins must be replaced one at a time, allowing three remaining pins to support ramp. Removal of two or more hinge pins may result in the weight of the ramp misaligning the remaining hinges, resulting in damage to ramp and possible injury or death to maintenance personnel.

When refueling, shut down the electrical system of the LARC. Observe the no smoking rule. Do not permit anyone to operate tools or equipment which may produce sparks near the refueling operation. Sparks or fire may ignite the diesel fuel and produce an explosion.

Before attempting to remove any compressed air system lines or components, relieve air pressure from system. Failure to do so may result in injury or possible death to maintenance personnel.

Before disconnecting a line in the hydraulic system, bleed the pressure from that portion of the line. Failure to do so may result in injury or possible death to maintenance personnel.

Be sure all cargo is secure, especially during rough seas.

WARNING
FIRE OR EXPLOSION HAZARD

SERIOUS INJURY OR DEATH

may result if personnel fail to observe these safety precautions.

Hatches must be open before energizing any electrical circuits or starting engines. Do not smoke or use an open flame in the vicinity when servicing batteries as hydrogen gas, an explosive is generated. Use distilled water to maintain battery electrolyte level. Do not fill fuel tank while engine is running. Provide metallic contact between the fuel tank to prevent a static spark from igniting fuel.

Fuel oil and other petroleum products are highly volatile in extreme heat. To minimize the possibility of explosion, wipe up all spills at once, see that fuel lines and valves are not leaking and pump bilges regularly.

Volatile materials will not be brought aboard; electrical circuits will not be energized; fuel tanks will not be topped off; and engines will not be started before CO_2 fire fighting equipment is available and operative. Observe NO SMOKING rules when refueling. Do not work on live circuits. Tag circuit and warn other personnel not to energize the circuit. Never use a blow torch or other similar means for heating fuel or oil lines.

Prior to cutting or welding on the ramp, remove drain plugs on both sides of the ramp and check if ramp interior is primer coated. If primer coated, flush thoroughly with steam, carbon dioxide, or water. Do not reinstall drain plugs until the cutting and/or welding operation is completed. Failure to take this precaution may result in explosion of accumulated primer vapors.

WARNING
ASPHYXIATION DANGER

Be sure engine room ventilators are open when operating the engine(s). The engine exhaust gases contain carbon monoxide, which is a colorless, odorless, and poisonous gas.

When working inside the hydraulic oil supply tank, a portable-type circulating blower should be used to prevent vapor accumulation. For extended work periods inside the tank, an air line tube respirator should be worn. Station an observer outside tank in case worker is overcome by fumes.

TECHNICAL MANUAL
No. 55-1905-217-34

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *8 October 1974*

DIRECT AND GENERAL SUPPORT MAINTENANCE MANUAL

LANDING CRAFT, MECHANIZED, STEEL, DED

OVERALL LENGTH 74 FEET, MOD 1, MARK VIII,

NAVY DESIGN LCM-8

(GUNDERSON BROS. ENGINEERING CORP,

MARINETTE MARINE CORPORATION,

AND ROHR CORPORATION)

NSN 1905-00-935-6057

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Scope

a. These instructions are published for the use of direct and general support maintenance personnel maintaining the Landing Craft, design LCM (8) MOD-1 (fig. 1-1). The instructions provide information on the maintenance of the equipment which is beyond the scope of the tools, personnel, or supplies normally available to using organizations.

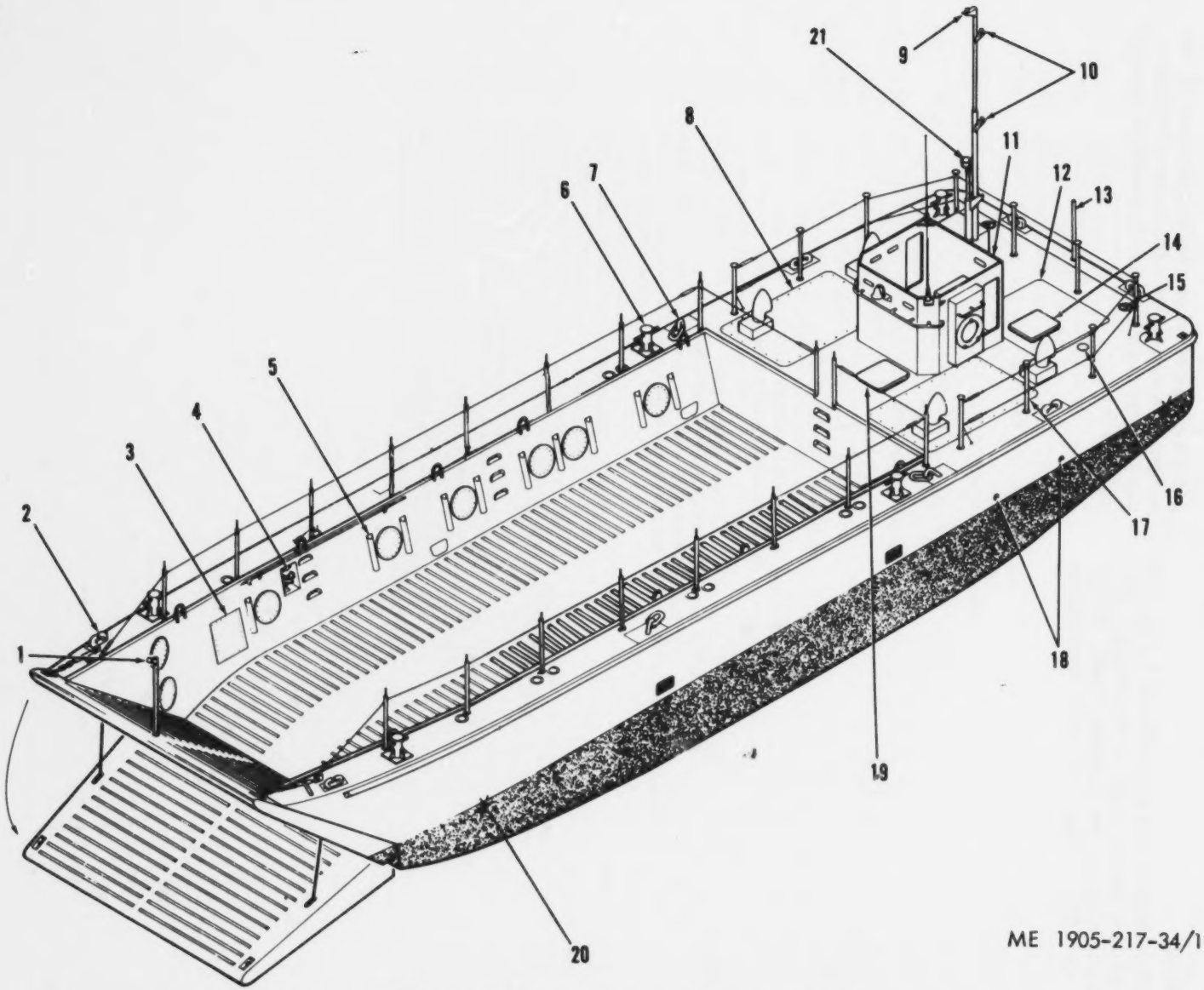

Figure 1-1. Landing craft, mechanized, diesel, design LCM (8) Mod-1-hull nos. 8540 through 8560 and 8580 through 8618.

Key to figure 1-1.

1. Bow/anchor light
2. 15-inch chock
3. Winch access plate
4. Ramp hand pump and control valve
5. Pipeguard
6. 12-inch bitt (3 each side)
7. Landing craft lifting eye (1 each side)
8. Starboard engine access
9. Masthead light
10. Not-under-command lights
11. Pilot house
12. Lazarette cover plate
13. Stern light and mast
14. Lazarette hatch
15. Emergency tiller deck plates
16. Fuel fill port (full)
17. Port engine access
18. Engine exhaust ports
19. Engine room hatch
20. Draft marks
21. Induction compass transmitter

b. Appendix A contains a list of publications applicable to the LCM (8) Mod-1 vessel. The maintenance allocation chart is contained in TM 55-1905-217-12.

1-2. Maintenance Forms and Records

Maintenance forms and records that you are required to use are explained in TM 38-570.

1-3. Reporting of Errors

You can improve this manual by calling attention to errors and by recommending improvements, using DA Form 2028 (Recommended Changes in Publications), or by a letter, and mail directly to the Commanding General, U. S. Army Troop Support and Aviation Materiel Readiness Command, ATTN: DRSTS-MTPS, 4300 Goodfellow Blvd., St. Louis, Missouri 63120. A reply will be furnished directly to you.

Section II. DESCRIPTION AND DATA

1-4. Description

A general description of the Landing Craft, design LCM (8) MOD-1, the location and description of the identification and instruction plates, and information on the differences in models are contained in the Operator and Organizational Maintenance Manual, TM 55-1905-217-12, paragraph 1-7 and 1-8. The repair and maintenance paragraphs of this manual contain detailed descriptions of the LCM (8) MOD-1 components.

1-5. Differences in Models

a. General. Landing Craft LCM (8) MOD-1 have been manufactured by difference contractors as follows:

Contractor	*Hull Registry Numbers*
Marinette Marine Corp	LCM-8500 thru LCM-8519
Gunderson Bros. Engineering Corp.	LCM-8520 thru LCM-8539
Rohr Corporation	LCM-8540 thru LCM-8560
Rohr Corporation	LCM-8580 thru LCM-8618

b. Components. Refer to Operator and Organizational Maintenance Manual TM 55-1905-217-12.

c. Maintenance. There are some differences in maintenance procedures due to difference components installed in the vessels. Maintenance procedures which are not designated by hull numbers are common to all vessels.

1-6. Tabulated Data

a. General. This paragraph contains all the maintenance data pertinent to direct and general support maintenance personnel.

b. Propulsion Units Classification and Rating.

Type	Twin 6-71, 2 Cycle Diesel
Displacment	851.2 Cu. Inch Total Displacement
Models	12005A, 12006A
Propeller Shaft Rotation: (As Viewed From Output Flange)	Stbd.—Clockwise (For R. H. Propeller) Port-Counterclockwise (For L. H. Propeller)
Weight Dry (Approximate)	5860 Pounds
Transmission	Allison Hydraulic
Transfer Gear:	
Type	Detroit Diesel
Reduction Ratio	2:1
Lube Oil Capacity	18 Qts.
Lube Oil Flow	7 Gal/Min
Starter	Electric 24 Volt, Outboard Engine; Hydraulic Starter-Inboard Engine
Maximum Installation Angle	0-20°
Rating (100° F 29 In Hg.)	300 Shp at 1800 RPM Continuous
Air Consumption (Total)	1275 CFM
Cooling System (Keel Cooling(Eng:	
Heat Rejection to Coolant	7,150 Btu/Min
Fresh Water Capacity	9 Gallons
Fresh Water Flow (To Keel Cooler)	57 Gpm
Maximum Pressure Drop Through Keel Cooler	6 Psi
Raw Water Flow (Auxiliary Raw Water Pump)	22 Gpm
Max. Pump Pressure (Raw Water)	10 Psi
Fuel System/Eng:	
Fuel Consumption	21.5 Gph
Pump Flow	90 Gph
Max. Inlet Restriction at Pump	6 In. Hg. (Clean Filter)

Exhaust System/Eng:
Gas Flow ..... 45.0 Lbs/Min
Temperature ..... 730° F.

c. Alternators (2) Classification and Rating.

Voltage ..... 24 volts
Amperes 70
Drive ..... Belt

d. Hydraulic Starting System Classification and Rating.

Operating pressures ..... 3000 psi (approximate)
Engine driven pump by pass valve opens ..... 2900—3300 psi
Relief valve setting (hull no. 8520 thru 8560 and 8580 thru 8618) ..... 3400 psi

e. Hydraulic Steering System Classification and Rating.

Relief valve setting (hull no. 8500 thru 8519) ..... 1500 psi
Relief valve setting (hull no. 8520 thru 8560 and 8580 thru 8618) ..... 1050 psi
Flow control valve limit (hull no. 8500 thru 8519) .... 2.5 GPM maximum
Flow control valve limit (hull no. 8520 thru 8539) .... 2 GPM maximum

f. Ramp Hoist System Classification and Rating.

Winch rating (hull no. 8500 thru 8519) ..... 14,250 lbs pull at 2000 psi
Winch rating (hull no. 8520 thru 8560 and 8580 thru 8618) ..... 22,000 lbs pull at 1900 psi
Relief valve setting (hull no. 8500 thru 8519) ..... 2000 psi
Control valve setting (hull no. 8520 thru 8560 and 8580 thru 8618) ..... 2100 psi

g. Bilge Pumps Classification and Rating.

Model L200—Port side ..... 280 GPM
Model L130—Port side ..... 180 GPM
Model R130—Starboard side .. 180 GPM
Hull nos. 8540 thru 8560 and 8580 thru 8618 contain clutch driven bilge pumps that can be disengaged when not required.

h. Time Standards. Table 1-1 lists the number of man-hours required under normal conditions to perform the indicated repair for the Landing Craft. The components are listed by functional index. The items listed are not intended to be rigid standards, but under ideal conditions with highly skilled mechanics, most of the operations can be accomplished in less time. However, under adverse conditions the operations will take longer.

i. Engine Repair and Replacement Standards. Table 1-1 lists the manufacturer's sizes, tolerances, desired clearances, and the maximum allowable wear and the maximum allowable clearances for the landing craft.

j. Bolt and Nut Torque Data for Diesel Engine, Model 12005A and 12006A.

(1) Table 1-2 is a listing of the standard bolt and nut torque specifications which should be observed in all cases unless specifically listed in table 1-3.

(2) Table 1-3 is a listing of all of the exceptions to the bolt and nut torque specifications listed in table 1-2.

Table 1-1. Engine Repair and Replacement Standards

Component	Manufacturers dimensions and tolerances in inches		Desired clearance		Maximum * allowable wear and clearances
	Minimum	Maximum	Minimum	Maximum	
CYLINDER BLOCK					
Block bore					
Diameter	4.6265	4.6275	.....	.....	.....
Out of round	.....	0.0010	.....	.....	0.0030
Taper	.....	0.0010	.....	.....	0.0020
Cylinder liner counterbore					
Diameter	5.0460	5.0485	.....	.....	.....
Depth	0.4785	0.4795	.....	.....	.....
Main bearing bore					
Inside diameter	3.8120	3.8130	.....	.....	.....
Top surface of cylinder block					
Center line of crankshaft to top of cylinder block distance	16.1840	16.1890	.....	.....	16.1760 min.
Flatness-transverse	.....	.....	.....	.....	0.0030
Flatness-longitudinally	.....	.....	.....	.....	0.0090
Depth of counterbores (top surface)					
Cylinder head seal strip groove	0.0920	0.1070	.....	.....	.....
Large water holes (between cylinders)	0.1090	0.1200	.....	.....	.....
Small water holes (at ends)	0.0870	0.0980	.....	.....	.....

Table 1-1. Engine Repair and Replacement Standards

Component	Manufacturers dimensions and tolerances in inches		Desired clearance		Maximum • allowable wear and clearances
	Minimum	Maximum	Minimum	Maximum	
CYLINDER LINERS					
Outside diameter	4.6250	4.6260	.....	.....	.....
Inside diameter	4.2495	4.2511	.....	.....	.....
Clearance-Liner-to-block bore	.....	.....	0.0005	0.0025	0.0030
Out-of-round-liner inside diameter	.....	0.0020	.....	.....	0.0030
Taper-liner inside diameter	.....	0.0010	.....	.....	0.0020
Depth of liner flange BELOW block	0.0465	0.0500	.....	.....	0.0500
Variation in height between adjacent liners	.....	0.0020	.....	.....	0.0020
CYLINDER HEAD					
Flatness-transverse	.....	.....	.....	.....	0.0040
Flatness-longitudinally	.....	.....	.....	.....	0.0100
Distance between top deck and fire deck	3.5560	3.5680	.....	.....	3.5360
WATER NOZZLES	1/32 re-cessed	Flush	.....	.....	.....
CAM FOLLOWER BORES	1.0620	1.0630	.....	.....	1.0650
EXHAUST VALVE SEAT INSERTS					
Seat width (30°)	1/16	3/32	.....	.....	3/32
Valve seat runout	.....	0.0020	.....	.....	0.0020
EXHAUST VALVES					
Stem diameter	0.3417	0.3425	.....	.....	0.3405
Valve head to cylinder head (30°)	0.0020 recessed	0.0280 protrusion	.....	.....	.....
VALVE GUIDES					
Height above cylinder head	1-19/32	1-19/32	.....	.....	1-19/32
Diameter, inside	0.3445	0.3455	.....	.....	0.3465
Clearance, steam to guide	.....	.....	0.0020	0.0038	0.0060
ROCKER ARMS AND SHAFTS					
Rocker shaft diameter	0.8735	0.8740	.....	.....	.....
Rocker arm shaft bushing inside diameter	0.8750	0.8760	.....	.....	.....
Clearance, shaft to bushing	.....	.....	0.0010	0.0025	0.0040
CAM FOLLOWERS					
Diameter	1.0600	1.0610	.....	.....	.....
Clearance, follower to head	.....	.....	0.0010	0.0030	0.0060
CAM FOLLOWER ROLLERS AND PINS					
Clearance, pin to bushing	.....	.....	0.0013	0.0021	0.0100 (horiz)
Side clearance, roller in follower	.....	.....	0.0150	0.0230	0.0230
CRANKSHAFT					
Journal diameter, main bearing	3.499	3.5000	.....	.....	.....
Journal diameter, connecting rod	2.749	2.750	.....	.....	.....
Journal out-of-round	.....	0.00025	.....	.....	0.0010
Journal taper	.....	0.0005	.....	.....	0.0015
**Runout on journals—total indicator reading (mounted on No. 1 and No. 7 journals)					
At No. 2 and No. 6 journals	.....	0.0020	.....	.....	.....
At No. 3 and No. 5 journals	.....	0.0040	.....	.....	.....
At No. 4 journal	.....	0.0060	.....	.....	.....
Thrust washer, thickness	0.1205	0.1220	.....	.....	.....
End thrust clearance (end play)	.....	.....	0.0040	0.0110	0.0180
MAIN BEARINGS					
Bearing inside diameter (vertical axis)	3.5014	3.5034	.....	.....	.....
Clearance-bearing-to-journal	.....	.....	0.0014	0.0044	0.0060
Bearing thickness 90° from parting line	0.1548	0.1553	.....	.....	0.1530 (min.)
CONNECTING ROD BEARINGS					
Inside diameter (vertical axis)	2.7514	2.7534	.....	.....	.....
Clearance-bearing-to-crankshaft journal	.....	.....	0.0014	0.0044	0.0060
Bearing thickness, 90° from parting line	0.1548	0.1553	.....	.....	0.1530 (min.)
PISTON AND RINGS					
Piston:					
Height (centerline of bushing-to-top of piston)	3.5130	3.5180	.....	.....	.....
Diameter:					
At top	4.2190	4.2220	.....	.....	
At skirt (below ring grooves to bottom)	4.2433	4.2455	.....	.....	

Table 1-1. Engine Repair and Replacement Standards

Component	Manufacturers dimensions and tolerances in inches		Desired clearance		Maximum allowable wear and clearances
	Minimum	Maximum	Minimum	Maximum	
Clearance-piston skirt-to-liner	.....	.....	0.0040	0.0078	0.0120
Out-of-round	.....	0.0005	.....	.....	.....
Taper	.....	0.0005	.....	.....	.....
Compression rings:					
Gap	.....	.....	0.0180	0.0430	0.0600
Clearance-ring-to-groove:					
Top ring	.....	.....	0.0095	0.0130	0.0220
No. 2	.....	.....	0.0075	0.0110	0.0150
No. 3 and 4	.....	.....	0.0055	0.0090	0.0130
Oil control rings:					
Gap	.....	.....	0.0080	0.02330	0.0430
Clearance-ring-to-groove	.....	.....	0.0015	0.0055	0.0080
PISTON PINS					
Diameter	1.4996	1.5000	.....	.....	1.4980
Pin-to-piston clearance	.....	.....	0.0025	0.0034	0.0100
Pin-to-rod bushing clearance	.....	.....	0.0015	0.0024	0.0100
Length	3.6050	3.6200	.....	.....	.....
Pin-to-retainer end clearance (retainer with lock ring)	.....	.....	0.0160	0.0640	0.0640
PISTON PIN BUSHINGS					
Inside diameter	1.5025	1.5030	.....	.....	1.5050
CONNECTING ROD					
Inside diameter upper bushing	1.5015	1.5020	.....	.....	1.5080
Normal rod side clearance	.....	.....	0.0060	0.0120	.....
CONNECTING ROD BEARINGS					
Inside diameter	2.7514	2.7534	.....	.....	.....
Clearance-bearing-to-crankshaft journal	.....	.....	0.0014	0.0044	0.0060
Bearing thickness-90° from parting line	0.1548	0.1553	.....	.....	0.1530
CAMSHAFT					
Shaft diameter-at-bearings					
Front and rear	1.4970	1.4975	.....	.....	.....
Center and intermediate	1.4980	1.4985	.....	.....	.....
Shaft diameter-at gear	1.1875	1.1880	.....	.....	.....
Length-thrust bearing end journal	2.8740	2.8760	.....	.....	.....
End thrust	0.0040	0.0120	.....	.....	.....
Thrust washer thickness	0.1200	0.1220	.....	.....	.....
BALANCE SHAFT					
Shaft diameter at bearings	1.4970	1.4975	.....	.....	.....
Shaft diameter at gear	1.1875	1.1880	.....	.....	.....
Length-thrust bearing end journal	2.8740	2.8760	.....	.....	.....
End thrust	0.0040	0.0120	.....	.....	0.0180
Thrust washer thickness	0.1200	0.1220	.....	.....	.....
CAMSHAFT AND BALANCE SHAFT BEARINGS					
Inside diameter					
Front and rear	1.5000	1.5010	.....	.....	.....
Center and intermediate	1.5010	1.5030	.....	.....	.....
Clearance-bearings-to-shaft					
Front and rear (next to flange)	.....	.....	0.0025	0.0040	0.0069
Center and intermediate	.....	.....	0.0025	0.0050	0.0090
Outside diameter of bearings					
Front and rear	1.1880	2.1885	.....	.....	.....
Intermediate	2.1840	2.1860	.....	.....	.....
Diameter of block bore	2.1875	1.2885	.....	.....	.....
Clearance-bearings-to-block	.....	.....	0.001	0.0005	.....
Front and rear	.....	.....	press	loose	
Intermediate					
CAMSHAFT AND BALANCE SHAFT GEARS					
Backlash	.....	.....	0.0030	0.0080	0.010
Gear inside diameter	1.1865	1.1875	.....	.....	.....
Clearance-gear-to-shaft	.....	.....	0.0015	0.0000	.....
			press		

Table 1-1. Engine Repair and Replacement Standards

Component	Manufacturers dimensions and tolerances in inches		Desired clearance		Maximum * allowable wear and clearances
	Minimum	Maximum	Minimum	Maximum	
IDLER GEAR					
Backlash	.....	.....	0.0030	0.0080	0.010
Preload-variation on pull 2 lbs. 11 oz.	½ lb	6¾ lbs.	.....	.....	½-6¾ lbs.
CRANKSHAFT TIMING GEAR					
Backlash	.....	.....	0.0030	0.0080	0.010
Gear inside diameter	4.7490	4.7500	.....	.....	.....
Clearance-gear-to-crankshaft	.....	.....	0.001 press	0.001 loose	.....
BLOWER DRIVE GEAR					
Backlash	.....	.....	0.0030	0.0080	0.010
Gear-to-hub fit	.....	.....	0.0005 press	0.0010 loose	.....
Support-to-end plate	.....	.....	0.0005 press	0.0025 loose	.....
Support bushing inside diameter	1.6260	1.6265	.....	.....	.....
Hub diameter-at bushing	1.6240	1.6250	.....	.....	.....
Hub-to-support bushing clearance	.....	.....	0.0010	0.0025	0.0050
Hub-to-cam clearance	.....	.....	0.0020	0.0070	.....
End thrust	0.0050	0.0080	.....	.....	0.0100
BLOWER					
Backlash-timing gears	.....	.....	0.0005	0.0025	0.004
Oil seal (below end plate surface)	.....	.....	0.002	0.008	.....
Pin-dowel (projection beyond inside face of end plates)	.....	.....	0.380	.....	.....
Clearances					
Rotor to end plate-gear end	.....	.....	0.007	.....	.....
Rotor to end plate-front end	.....	.....	0.014	.....	.....
Rotor to housing-inlet side	.....	.....	0.015	.....	.....
Rotor to housing-outlet side	.....	.....	0.004	.....	.....
Trailing edge of upper rotor to leading edge of lower rotor	.....	.....	0.002	0.006	0.006
Leading edge of upper rotor to trailing edge of lower rotor	.....	.....	0.012	.....	.....

* These clearances also apply to oversize or undersize parts.

* * Runout tolerance given for guidance when regrinding the crankshaft. When the runout on adjacent journals is in the opposite direction, the sum must not exceed .003" total indicator reading. When the runout on adjacent journals is in the dame direction, the difference must not exceed .003" total indicator reading. When high spots of the runout adjacent journals are at right angles to each other, the sum must not exceed .004" total indicator reading or .002" on each journal.

Table 1-2. Standard Bolt and Nut Torque Specifications

Size nut or bolt	Torque (ft-lbs)	Size nut or bolt	Torque (ft-lbs)	Size nut or bolt	Torque (ft-lbs)
¼-20	7-9	7/16-20	57-61	3/4-10	240-250
¼-28	8-10	½-13	71-75	3/4-16	290-300
5/16-18	13-17	½-20	83-93	7/8-9	410-420
5/16-24	15-19	9/16-12	90-100	7/8-14	475-485
3/8-16	30-35	9/16-18	107-117	1-8	580-590
3/8-24	35-39	5/8-11	137-147	1-14	685-695
7/16-14	46-50	5/8-18	168-178		

(3) Table 1-4 is a listing of stud torque and height specifications. In all cases both the height and torque ranges are specified so that the mechanic can drive the stud to a point where both specifications are met.

(4) Table 1-5 is a listing of special plug torque specifications.

Table 1-3. Special Bolt and Nut Torque Specifications

Application	Size nut or bolt	Torque (lb-ft)
CYLINDER BLOCK		
End plate bolt	3/8-16	10-15
Hand hole cover	3/8-16	10-15
Main bearing bolt (boring)	5/8-11	165-175
Main bearing bolt (assy)	5/8-11	180-190
Main bearing nut (boring)	5/8-18	140-155
Main bearing nut (assy)	5/8-18	155-185
CYLINDER HEAD		
Cam follower guide bolt	1/4-20	12-15
Injector control shaft bracket bolt	1/4-20	10-12
Exhaust valve bridge adjusting screw lock nut	5/16-24	20-25
Injector clamp bolt	3/8-16	20-25
Injector clamp nut	3/8-24	20-25
Exhaust manifold outlet flange nuts (brass)	3/8-24	20-25
Water manifold nut	3/8-24	25-30
Fuel pipe nut	3/8-24	12-15
Lifter bracket bolt	7/16-14	55-60
*Threaded exhaust valve bridge guide (nylon insert)	7/16-14	46-50
Exhaust manifold nuts	7/16-20	30-35
*Fuel manifold connectors	7/16-20	30-35
Fuel manifold connector nuts	7/16-20	30-35
#Rocker shaft bolt	7/16-20	30-35
*Cylinder head bolts	1/3-13	90-100
*Cylinder head nuts	5/8-11	175-185
CRANKSHAFT		
O. P. bolt in aluminum flywheel housing & front cover	5/16-18	10-12
Crankshaft front cover	3/8-24	25-30
Connecting rod nut (lubrite)	7/16-20	60-70
Connecting rod nut (castellated)	7/16-20	65-75
Crankshaft front cover	1/2-13	80-90
Main bearing bolt	5/8-11	
Main bearing nut	5-8-18	155-185
Crankshaft end bolt	1-14	290-310
CAMSHAFT AND BALANCE SHAFT		
Blower drive coupling to gear hub bolt	5/16-24	20-25
Idler gear bearing retainer bolt	5/16-24	24-29
Cam and balancer shaft end bearing bolt	3/8-16	35-40
Flywheel housing to idler gear hub and spacer (self-locking bolt only)	3/8-16	40-45
Flywheel housing to idler gear hub and spacer (wired bolt only)	3/8-16	25-40
Balance weight cover bolt	3/8-16 & 24	25-30
Camshaft intermediate bearing lock screw	3/8-24	15-20
Balance weight to timing gear bolt	3/8-24	25-30
Blower drive gear hub bearing support bolts & nuts	3/8-24	25-30
Balance weight to timing gear bolt	3/8-24	25-30
Accessory drive to gear bolt (steel disc)	3/8-24	45-50

Application	Size nut or bolt	Torque (lb-ft)
Accessory drive to gear bolt (fiber disc)	3/8-24	35-39
Generator drive bearing retaining bolt	7/16-14	30-35
Generator drive oil seal retaining bolt	7/16-14	30-35
Tachometer drive cover bolt	7/16-14	30-35
Generator drive bearing retaining bolt	1/2-13	30-35
Generator drive oil seal retaining bolt	1/2-13	30-35
Tachometer drive cover bolt	1/2-13	30-35
Rocker shaft bolt	1/2-13	90-100
Idler gear and dummy hub bolt	1/2-13	80-90
Blower rotor gear retaining nut	1/2-20	55-65
Crankshaft end bolt	1-14	290-310
Camshaft and balancer shaft nut	11/8-18	300-325
Blower drive gear hub nut	11/2-16	50-60
FUEL INJECTOR		
Injector clamp stud	3/8-16	10-25
Injector clamp bolt	3/8-16	20-25
Injector clamp nut	3/8-24	20-25
Fuel pipe nut	3/8-24	12-15
*Fuel manifold connectors (nylon insert)	7/16-20	30-35
*Fuel manifold connectors (steel washers)	7/16-20	35-40
Fuel manifold connector nut	7/16-20	30-35
Rocker arm bracket bolt	1/2-13	90-100
Injector filter cap	5/8-24	65-75
Injector nut (crown valve)	15/16-24	55-65
Injector nut (needle valve)	15/16-24	75-85
AIR INTAKE		
Blower lower front bearing retaining bolt (allen head)	5/16-24	18
Blower drive plate-to-drive hub bolt	5/16-24	25-30
Blower drive hub-to-blower rotor gear bolt	5/16-24	25-30
Air inlet housing-to-blower housing bolt	3/8-16	16-20
Blower housing-to-cylinder block bolt (cast iron block)	7/16-14	55-60
Blower housing-to-cylinder block bolt (aluminum block)	7/16-14	35-40
Blower rotor timing gear bolt	7/16-20	55-65
Blower rotor timing gear bolt	1/2-20	55-65
LUBRICATION SYSTEM		
Oil pan bolts	5/16-18	10-12
Oil pump drive idler gear nut (marsden)	1/2-20	60-70
Oil pan drain plug	18mm	35-40
COOLING SYSTEM		
Water pump coupling bolt	5/16-24	18 min.
Water manifold nut	3/8-24	25-30
Raw water pump (Jabsco) drive gear retaining nut	5/8-18	25-30 max.
TORQUMATIC MARINE GEAR		
Planetary carrier bolt nuts	1/2"-20	130-140
Driven shaft forward bearing retainer nut, "M" type gear	1.967"-18	275-325
Drive flange nut, direct drive and "M" type gears	2"-18	275-325
Driven shaft forward bearing retainer nut, "MH" type gear	2.157"-18	350-400
Drive flange nut, "MH" type gear	2.548"-18	350-400
Flywheel bolts	9/16"-18	150-160
FLYWHEEL HOUSING		
Oil pan bolts	5/16-18	10-12
Flywheel housing bolts	3/8-16	25-30
**Idler gear hub and spacer	3/8-16	40-45
##Idler gear hub and spacer	3/8-16	25-40
Flywheel housing bolts	3/8-24	25-30
Lifter bracket bolts	7/16-14	55-60
Flywheel housing bolts	1/2-13	90-100
AIR BOX COVER		
Air box cover bolt	3/8-16	10-15
CONNECTING ROD		
Connecting rod nut (lubrite)	7/16-20	60-70
Connecting rod nut (castellated)	7/16-20	65-75

* Lubricate before assembling to cylinder head.

** Self-locking only.

75-85 lb-ft torque on the two bolts attaching load limit screw bracket (if used to the rocker arm shaft bracket).

Wired head only.

Lubricate at assembly with engine oil OE-30.

Table 1-4. Stud Torque and Height Specifications

Application	Torque (lb-ft)	Height
CYLINDER BLOCK		
Cylinder Head Stud	75 Min.	43/8"±1/32"
Main Bearing Stud	35-75	4"±1/32"
CYLINDER HEAD		
Injector Clamp Stud	10-25	.....
Water Manifold Stud	10-25	.....
Exhaust Manifold Stud	25-40	.....
COOLING SYSTEM		
Water Manifold Stud	10-25	.....

(5) Table 1-6 is a listing of spring specifications.

k. Wiring Diagrams. Figures 1-2, 1-3 and 1-4 are wiring diagrams for the respective landing craft.

Figure 1-2. Wiring Diagram-hull no. 8500 thru 8519.
(Located in Rear of Manual)

Table 1-5. Special Plug Torque Specifications

Application	• • Plug	Assembly data
Oil Gallery Plug	3/8" Dryseal P. T. F. Thd.	*Assemble with max. 1/16" protrusion from surface.
Cylinder Head Plug	3/8"-16	Assemble flush to 1/16" protrusion from surface.
Cylinder Head (Top)	½" P. T. F.—S. A. E. Short	Flush to 1/8" recessed.
Cylinder Head (End)	3/4" Dryseal P. T. F.—S. A. E. Short	Flush to 1/8" recessed.
Water Plug	1" N. P. T. F. Thd.	Assemble 2" to 2¼" below machined surface.
Water Plug	1 3/4"-16	75-100 lb-ft torque.
Oil Drain Plug	18 MM	35-40 lb-ft torque.

* After installation, a 7 / 32" rod inserted in oil line must pass inner face of plug.

• • Apply sealing compound to plugs used without gaskets.

Table 1-6. Spring Specifications

Spring	No. Coils	Wire Dia.	Approximate free length	Replace when load is less Than:
Cam Follower	11	.177"	2 5/8"	172 lbs. at 2 1/8"
Cam Follower	11 1/2	.177"	2 21/32"	133 lbs at 2 7/64"
Exhaust Valve	8 3/4	.162"	2 3/8"	135 lbs. at 1 49/64"

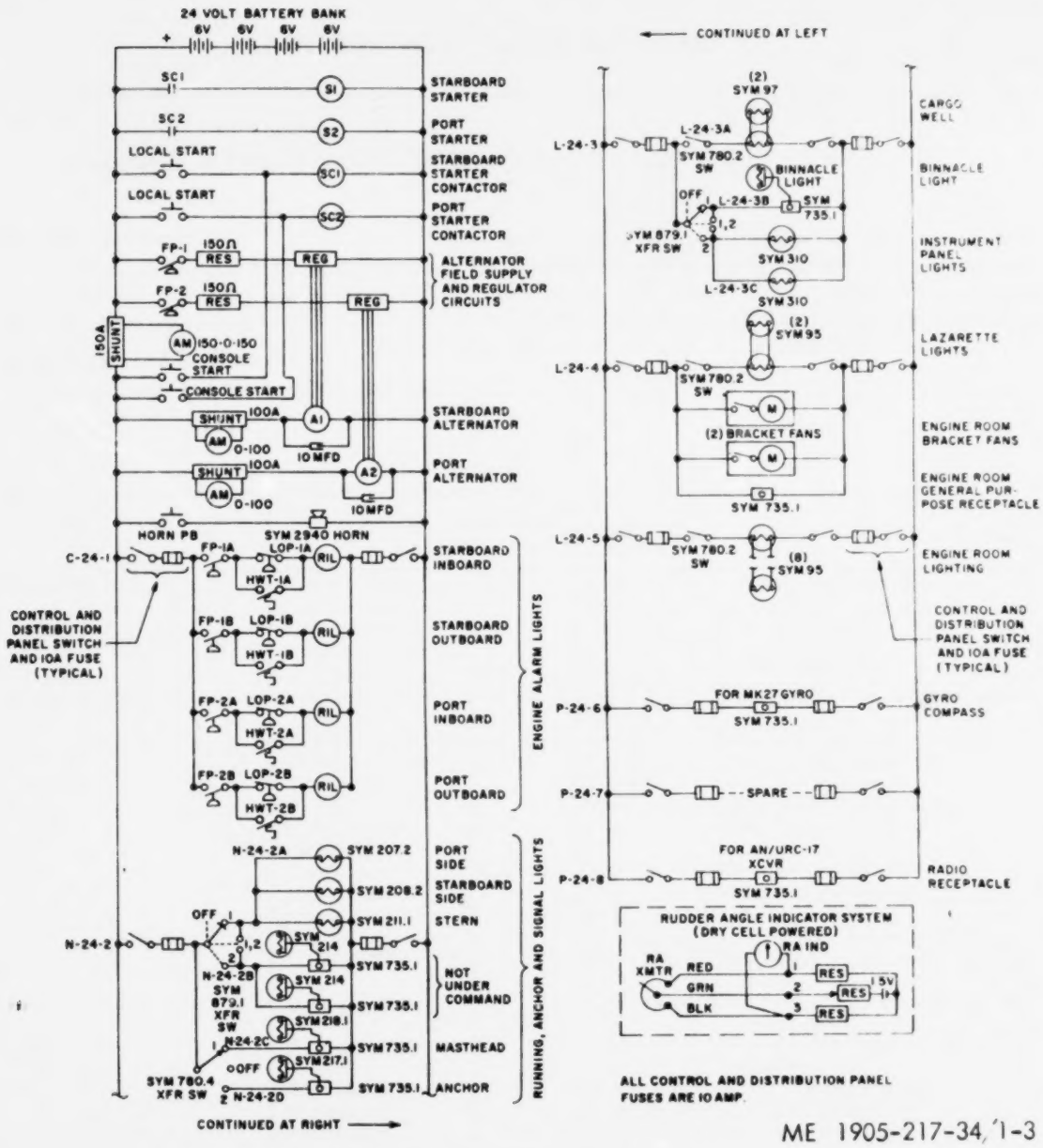

Figure 1-3. Wiring diagram-hull no. 8520 thru 8539.

Figure 1-4. Wiring diagram-hull nos. 8540-8560 and 8580-8618.
(Located in Rear of Manual)

CHAPTER 2

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. REPAIR PARTS, SPECIAL TOOLS, AND EQUIPMENT

2-1. Tools and Equipment

Tools and Equipment, issued with or authorized for organizational maintenance are listed in TM 55-1905-217-12, paragraph 4-6.

2-2. Special Tools and Equipment

Special Tools required to perform direct and general support maintenance of the Landing Craft are listed in table 2-1 of this manual. No special equipment is required for direct and general support maintenance. Special tools are listed and illustrated in TM 55-1905-217-34P.

Table 2-1. Special Tools

Item	FSN or Part Number	Reference		Use
		Fig. No.	Para. No.	
Seal installer handle	(72582)J1508-8		3-3*d* (1) (a)	Fuel pump seal installation.
Adapter	(72582)J1508-9		3-3*d* (1) (c)	Fuel pump seal installation.
Adapter	(72582)J6471-4		3-9*b*	Blower disassembly.
Adapter	(72582)J6471-10		3-9*b*	Blower disassembly.
Gear puller	(72582)J6270-1	3-31	3-9*b*	Blower disassembly.
Seal remover and installer	(72582)J6270-3		3-9*c* (10) (c) 3-9*e* (3)	Blower seal removal and installation.
Seal installer	(72582)J1682-13		3-9*e*	Blower seal installation.
Seal pilot	(72582)J6270-5		3-9*f* (2)	Blower seal installation.
Seal spacer installer	(72582)J1682-13		3-9*f* (2)	Blower seal installation.
Bearing installer	(72582)J6270-4		3-9*e*	Blower bearing installation.
Bearing installer	(72582)J6270-7	3-34	3-9*e*	Blower bearing installation.
Gear installer	(72582)J6270-8	3-34	3-9*e*	Blower gear installation.
Gear installer	(72582)J6270-6	3-34	3-9*e*	Blower gear installation.
	(72582)J6270-7	3-34	3-9*e*	Blower gear installation.
Feeler gage set	(72582)J1698-02	3-33	3-9*e*	Blower rotor clearance.
Bearing installer	(72582)J21068		3-4*e* (1)	Governor cover bearing installation.
Coupling tool	(72582)J1930		3-6*b*	Fresh water pump drive coupling removal.
Cam follower tool	(72582)J5840	3-54	3-14*b* (3) (a)	Cam follower and pin removal and installation.
Spring compressor tool	(72582)J7455		3-15*a* 3-15*d*	Valve spring removal and installation.
Spring tester	(72582)J9666		3-15*b* (1) (b)	Test valve spring tension.
Brush	(72582)J5437		3-15*b* (3) (a)	Clean valve guides
Valve guide installing tool	(72582)J9530		3-15*d*	Valve guide installation.
Valve seat tool	(72582)J4824-01	3-55	3-15*a*	Valve seat removal
Valve seat grinder set	(72582)J8165	3-56	3-15*c*	Valve seat refacing
Dial indicator	(72582)J8165-2		3-15*c*	Valve seat runout and concentricity
Gear puller	(72582)J3051		3-19*a*	Oil pump drive gear removal
Piston ring tool	(72582)J8128		3-20*a*	Piston ring removal
Tool set	(72582)J1513		3-20*a* 3-20*e*	Bushing removal and installation
Reaming tool set	(72582)J3071	3-73	3-20*e*	Piston pin bushing reaming
Reaming fixture	(72582)J5273		3-20*e*	Piston pin bushing reaming
Feeler gage set	(72582)J5488		3-20*e*	Checking piston to liner clearance
Holder	(72582)J7632		3-20*b* 3-20*e*	Connecting rod bearing removal and installation
Reamer tool set	(72582)J1686-02	3-73	3-20*e*	Reaming connecting rod bushings
Spray nozzle remover	(72582)J8995	3-74	3-20*e*	Spray nozzle removal

Table 2-1. Special Tools and Equipment (Continued)

Item	FSN or Part Number	Reference		Use
		Fig. No.	Para. No.	
Retainer installer	(72582)J4895-01		3-20*e*	Piston pin retainer installation
Liner tool	(72582)J1918-02	3-75	3-21*a*	Cylinder liner removal
Bore gage	(72582)J5347	3-77	3-21*c* (6)	Cylinder bore measurements
Ring gage	(72582)J5580-1		3-21*c* (6)	Cylinder bore measurements
Hold-down clamps	(72581)J21793		3-21*f* (3) 3-23*g*	Cylinder liner installation
Ring compressor	(72582)J3272-02			Piston ring installation
Oil seal installer	(72582)J9727		3-24*c*	Crankshaft rear oil seal installation
Handle	(72582)J3154-1		3-24*c*	Crankshaft rear oil seal installation
Tool	(72582)J4757		3-25*d*	Main bearing measurements
Camshaft gear puller	(72582)J1902-01		3-29*c*	Camshaft gear removal
Spacer	(72582)J6202-2		3-29*c*	Camshaft gear removal
Adapter plate	(72581)J6202-1		3-29*c*	Camshaft gear removal
Adapter	(72582)J8183		3-29*e*	Camshaft oil plug removal
Slide hammer	(72582)J6471-1		3-29*e*	Camshaft oil plug removal
Wrench	(72582)J4385-01	3-83	3-23*c*	Power transfer gear disassembly
Wrench	(72582)J4384-01		3-23*c*	Power transfer gear disassembly
Piston tool	(72582)J4746		3-26	Reverse gear piston removal and installation
			3-26	
			3-26	
Oil seal tool	(72582)J4700		3-26	Reverse gear oil seal removal and replacement
			3-26	
Adapter	(72582)J5901-2		3-26	Reverse gear pilot bearing removal
Oil seal protector	(72582)J6904-2	3-39	3-11*d*	Transmission oil pump oil seal installation
Piston tool	(72582)J7192	4-19	4-7*d*	Oil pump piston installation
Oil seal tool	(72582)J7191	4-20	4-7*d*	Oil pump oil seal installation
Spring installer	(96151)J600057		4-13*d*	Helm unit valve spring installation
Motor removal tool	(36581)B13009		4-16*c* and 4-17*c*	Remove motor assembly
Bearing puller	(36581)C13115		4-16*c* and 4-17*c*	Remove bearing from drum
Bushing installer	(36581)B1397		4-16*c* and 4-17*c*	Install bushing in drum

2-3. Maintenance Repair Parts

Direct and general support maintenance repair parts are listed and illustrated in TM 55-1905-217-34P.

Section II. TROUBLESHOOTING

2-4. General

a. This section contains troubleshooting information for locating and correcting most of the operating troubles which may develop in the landing craft. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine the probable causes and corrective actions to take. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests or inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective actions, notify your supervisor.

2-5. Troubleshooting

Refer to table 2-2. This table provides troubleshooting instructions at the direct and general maintenance levels. Refer to TM 55-1905-217-12, paragraph 3-6, for lower echelon troubleshooting.

NOTE

Before you use this table, be sure you have performed all applicable operating checks.

Table 2-2. Troubleshooting

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
Propulsion Engine
1. Engine will not turn over.
Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated.
Disassemble the engine to ascertain the extent of damage and the cause (para 3-13 thru 3-19).
2. Low cranking speed.
Step 1. Check electric starting motor
Overhaul electric starting motor (para 4-3).
Step 2. Check hydraulic starting system.
Refer to (paras 4-4 thru 4-9).
3. Low compression
Step 1. Check for sticking or burned exhaust valves.
Cylinder head must be removed and overhauled to correct this condition.
Step 2. Check for improper valve seating. Check for excessive valve-to-guide clearance, bent valve guide or carbon deposits.
Replace a worn or bent guide. Clean the carbon from the valve. Reface or replace the valve if necessary (para 3-15).
Step 3. Check for a bent or broken valve. Check for contact between the valve head and the piston as a result of incorrect valve clearance, or a defective spring. Check the valve guide, insert, cylinder head and piston for damage.
Replace damaged parts (para 3-15).
Step 4. Look for varnish deposits on valve stem. Check for a worn valve guide or excessive exhaust back pressure.
Reface the valve and insert or, if necessary, replace (para 3-15).
Step 5. Check for scored or scuffed valve stem. Check for a bent valve stem or guide, metal chips or dirt, or for a lack of lubrication.
Clean up the valve stem with crocus cloth wet with fuel oil or replace the valve. Replace the guide. When installing a valve, use care in depressing the spring so that the spring cap DOES NOT scrape the valve stem (para 3-15).
Step 6. See if all valves are bent. Check for a gear train failure, or for improper gear train timing.
Refer to para 3-15 and 3-17.
Step 7. See if compression rings are worn or broken.
Overhaul cylinder and replace rings (para 3-20).
Step 8. See if blower is not functioning.
Overhaul blower (para 3-9).
4. No fuel or insufficient fuel
Step 1. Look for obstruction in fuel lines or filters.
Disassemble and clean out all fuel lines. Service filters and strainers. (TM 55-1905-217-12, para 4-27).
Step 2. Check for faulty fuel pump.
Replace fuel pump TM 55-1905-217-12 (para 4-29).
5. Governor instability (hunting).
Check for faulty governor and/or linkage to injectors.
Repair and/or overhaul governor (para 3-4).

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6. Excessive crankcase pressure
   Step 1. Check for cylinder blowby.
   Replace rings, piston or liner (paras 3-20 and 3-21).
   Step 2. Check for leakage at blower gasket.
   Replace blower gasket (para 3-9).
   Step 3. See if cylinder block end plate gasket is leaking.
   Replace end plate gasket (para 3-30).
7. High oil consumption
   Step 1. Check for worn oil control rings.
   Replace rings (para 3-20).
   Step 2. Check for scarred liners, rings or pistons.
   Replace rings, pistons or liners (para 3-20).
   Step 3. Check blower oil seal for leaks.
   Repair blower (para 3-9).
8. Low oil pressure.
   Step 1. Check oil pump.
   Overhaul oil pump (para 3-19).
   Step 2. Check oil pressure regulator.
   Repair oil pressure regulator (para 3-19).
9. Incompletely burned fuel (black exhaust smoke).
   Step 1. Check for obstruction in exhaust piping, TM 55-1905-217-12 (para 4-40).
   Disassembly exhaust system components, repair or replace parts. (TM 55-1905-217-12, paras 4-22, 4-40).
   Step 2. Check for faulty blower.
   Clean liner parts; remove obstruction to blower screen. (para 4-37 of TM 55-1905-217-12).
   Step 3. Check for clogged blower screen or dirty cylinder liner parts.
   Overhaul blower (para 3-9).
10. High engine coolant temperatures.
   Step 1. Check for faulty fresh water pump.
   Repair fresh water pump (para 3-6).
   Step 2. Check for obstructed fresh water cooling system.
   Disassemble, clean and reassemble component parts of fresh water cooling system.
   Step 3. Check for damaged keel cooler.
   Replace keel cooler (para 3-8).
11. High muffler temperatures
   Step 1. Check for faulty raw water pump.
   Repair raw water pump (para 3-7).
   Step 2. Check for obstructed raw water cooling system.
   Disassemble raw water (muffler) cooling system, clean, and reassemble. Refer to TM 55-1905-217-12, (para 4-40).
   Step 3. Check for damaged muffler.
   Replace muffler (TM 55-1905-217-12, para 4-40).
12. Malfunction of power take-off assembly (ramp hoist pump drive).
   Step 1. Check for worn clutch.
   Replace clutch (para 3-12).
   Step 2. Check clutch release mechanism.
   Repair clutch release mechanism (para 3-12).
   Step 3. Check for broken drive or other internal damage.
   Overhaul power take-off assembly (para 3-12).

Transmission and Transfer Gear

1. Gear inoperative (Drive shaft does not rotate) Condition A—Selector valve in forward position.
   Step 1. Check for low oil pressure.
   Refer to 2. Low oil pressure below.
   Step 2. Check for worn forward clutch facings.
   Replace if found excessively worn (para 3-26).
   Step 3. Check for improper dump valve operation.
   Check the dump valves for varnish or other foreign material that would cause poor seating or restrict movement (para 3-26).
   Step 4. Inspect the clutch plate for damage.
   Clutch plate may be sheared or loose on the hub and require replacing (para 3-26).
   Step 5. Examine the reduction gears and bearings for damage.
   Replace damaged parts found (para 3-26).

Condition B—Selector valve in reverse position.
   Step 1. Check for low oil pressure.
   Refer to 2. Low oil pressure below.
   Step 2. Inspect the clutch facings.
   Replace if found excessively worn (para 3-26).
   Step 3. Check for damaged planetary assembly.
   Disassemble and repair with new parts (para 3-26).

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Step 4. Examine the reduction gears and bearings for damage.
Replace damaged parts found (para 3-23).

2. Low oil pressure.

Condition A—When selector valve is placed in any position: forward, neutral or reverse.

Step 1. Check for faulty oil pump relief valve.
Repair relief valve (para 3-11).

Step 2. Check for faulty oil pump.
Overhaul oil pump (para 3-11).

Step 3. Check for defective dump valve.
Repair marine gear dump valve (para 3-26).

Condition B—When selector valve is placed in forward.

Step 1. Check for broken or worn forward piston seals.
Remove and replace the forward piston seal rings (para 3-26).

Step 2. Check for leaking pilot bearing oil seal.
Remove and replace the pilot bearing oil seal (para 3-26).

Step 3. Check for improper operation of dump valve.
Remove the dump valve and clean and inspect the seating surfaces. Replace damaged parts (para 3-26).

Step 4. Check for faulty flywheel.
Inspect the flywheel and replace loose or missing passage plugs (para 3-19).

Check for the emergency engagement bolts for tightness. Tighten loose bolts (para 3-26)

Step 5. Check for damaged drive shaft seal rings.
Replace if found worn or damaged (para 3-26).

Condition C—When selector valve is placed in reverse.

Check for broken or worn reverse piston seals.
Remove and replace the reverse piston seal rings (para 3-26).

. Gear dragging: Drive shaft rotates with selector valve in neutral.

Condition A—After moving selector valve from forward to neutral.

Step 1. Check for sticking forward clutch plate. Inspect the clutch plate for wear.
If facings have worn smooth the clutch plate should be replaced (para 3-26).

Step 2. Check the forward clutch plate for broken or loose facing material. This material may lodge between the clutch plate and piston or the reaction plate.
Refer to para 3-26.

Step 3. Inspect the forward piston drive pins for burrs that could prevent the piston from moving into the disengaged position.
Burred pins should be replaced with new pins (para 3-26)

Step 4. Check the flatness of the forward piston.
Replace if warped (para 3-26)

Step 5. Inspect the planetary assembly for areas of bind.
Overhaul and replace damaged parts.

Step 6. Inspect the dump valve for varnish or foreign material which may prevent the valve from functioning properly.
Clean or replace damaged parts (para 3-26).

Step 7. Inspect the seal rings on the drive shaft for wear or breakage.
Replace faulty parts (para 3-26).

ondition B—After moving selector valve from reverse to neutral.

Step 1. Inspect the reverse clutch plate for wear.

Step 2. Check the reverse clutch plate for broken or loose facing material. This material may lodge between the clutch plate and piston or the reaction plate.
Refer to para 3-26.

Step 3. Inspect the reverse piston drive pins for burrs that could prevent the piston from moving into the disengaged position.
Burred pins should be replaced with new pins (para 3-26).

Step 4. Check the flatness of the reverse piston.
Replace if warped (para 3-26).

Step 5. Inspect the planetary gear assembly for areas of bind.
Overhaul and replace damaged parts (para 3-26).

Gear slipping or slow to engage.

ondition A—With selector valve in forward position.

Step 1. Check for low oil pressure.
Refer to 2. Low oil pressure above.

Step 2. Check the flatness of the forward piston and reaction plate.
Replace if badly warped (para 3-26).

Step 3. Inspect the clutch facings for wear.
If the facings are badly worn the clutch plate should be replaced (para 3-26).

Step 4. Inspect the dump valves for varnish or foreign material which may prevent the valves from functioning properly.
Clean or replace damaged parts (para 3-26).

ondition B—With selector valve in reverse position.

Step 1. Check for low oil pressure.
Refer to 2. Low oil pressure above.

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Step 2. Check the flatness of the reverse piston and reaction plate.
Replace if badly warped (para 3-26).
Step 3. Inspect the clutch facings for wear.
If the facings are badly worn, the clutch plate should be replaced (para 3-26).

Alternator

1. Alternator fails to charge.
Step 1. Check for open isolation diode.
Disassemble alternator and replace isolation diode (para 4-2).
Step 2. Check for open rotor winding.
Disassemble alternator and verify rotor winding continuity. Replace rotor if open (para 4-2).
Step 3. Check for sea water from leaking bilge pump shorting out voltage regulator.
Replace or repair leaking gland (TM 55-1905-217-12, para 4-101*b*).
2. Low or unsteady charging rate.
Step 1. Check for open, grounded, or shorted turns in stator coils.
Disassemble alternator and replace stator (para 4-2).
Step 2. Check for grounded or shorted turns in rotor winding.
Disassemble alternator and replace rotor (para 4-2).
Step 3. Check for open or shorted rectifier diode(s).
Disassemble alternator and determine which diode plate has faulty diode. Replace diode(s) (para 4-2).
3. Noisy alternator.
Check for worn bearings.
Disassemble alternator and replace worn or defective bearings (para 4-2).

Electric Starting Motor

1. Starter does not crank engine adequately.
Step 1. Check for damaged brushes.
Replace brushes (para 4-3).
Step 2. Check for worn commutator.
Repair commutator (para 4-3) Replace armature if necessary.
Step 3. Check for open field coils or armature winding.
Overhaul starting motor (para 4-3).
Step 4. Check for damaged Bendix drive.
Replace Bendix drive (para 4-3).
Step 5. Check for worn bearings.
Replace bearings and overhaul starting motor (para 4-3).

Hydraulic Starting System

1. Cranking speed too low.
Check for excessive internal leakage in starting motor.
Check for broken cylinder, scored face (port plate or cylinder), broken or weak cylinder spring and damaged seal surfaces.
Replace parts as necessary (para 4-6).
2. Loss of fluid from reservoir.
Check for worn starting motor shaft seals.
Remove housing plate and examine inside of housing. If evidence of system fluid is found, replace shaft seal (para 4-6).
3. Hydraulic starting motor turns but engine does not.
Check for damaged, overrunning clutch.
Replace Bendix drive (para 4-6).
4. Hand pump fails to charge system
See if piston seal rings are damaged.
Replace seal rings (para 4-9).
5. Loss of accumulator precharge (nitrogen).
Step 1. Check for damaged seal ring or piston.
Release all hydraulic pressure before removing the accumulator from the system and release nitrogen pressure; then disassemble the accumulator. Replace defective piston sealing rings (para 4-8).
Step 2. Check for damaged seal ring between tube and end cap.
Apply liquid soap on threaded end of accumulator at end cap. Bubbling of soap indicates a leak past end cap seal. Release nitrogen before replacing seal (para 4-7).
6. High pressure in system (3500 psi or above).
See if unloading valve is operating properly.
Clean and adjust to specified operating pressure. Check that the plunger is not binding or sticking.

NOTE

There is a 500 lb differenital between cut-out and cut-in.

Steering System

1. Steering wheel difficult to turn.
See if dirt has become trapped in helm unit.
Disassemble unit and thoroughly clean all surfaces of spool. Repair as necessary (para 4-13).
2. Steering wheel continues to turn after being started and released.
Same as 1 above.
Same as 1 above.

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3. Wheel turns but rudder does not.
Check for Helm unit failure.
Disassemble helm unit. Clean surfaces in both sections and inspect for damaged parts. Replace parts as necessary (para 4-13).
4. Noisy operation of pump.
Step 1. See if pump intake is partially blocked.
Service intake strainers. Check internal flow path for cleanliness.
Step 2. Look for air leaks at the intake or shaft seal. (Oil in reservoir would probably be foamy).
Replace seals and be certain all connections are tightened properly (para 4-11).
Step 3. Check for coupling misalignment.
See if shaft seal bearing or other parts have been damaged. Replace damaged parts and realign the coupled shafts (para 4-11).
5. Oil too hot.
Check for relief valve leaking at high pressure.
Disassemble and clean, then repair or replace valve (para 4-21).
6. Rudder angle indicator does not operate.
Check for dead battery.
Replace 1.5V battery (Hull nos. 8520 thru 8560 and 8580 thru 8618).

Ramp Hoist Hydraulic System

1. Nosiy operation of pump.
Step 1. Check for partially blocked pump intake.
Service the intake strainers. Check internal flow path for cleanliness.
Step 2. Check for binding in motor or gearbox.
Disassemble and inspect for faulty bearings or gears. Replace faulty parts (para 4-18).
3. Brake does not release.
Step 1. Check for leaking piston seals or "O" rings.
Disassemble and replace seals and packings (paras 4-16 and 4-17).
Step 2. Check for seized driving and driven plates.
Disassemble and repair as required (paras 4-16 and 4-17).
4. Erratic action of winch.
Check for inoperative relief valve.
Disassemble and inspect bushings, plungers, and pistons for defects. Replace defective parts (paras 4-16 and 4-17).
5. Loss of oil in motor.
Check for defective seal.
Replace seal (paras 4-16 and 4-17).

Section III. REMOVAL AND INSTALLATION OF MAJOR COMPONENTS AND ASSEMBLIES

2-6. General

This section contains removal and installation instructions for the propulsion units, engine room access hatches, and winches. For removal and installation of the transmission (torquematic marine gear) refer to paragraphs 3-23 and 3-26. For removal and installation of the ramp hoist winch, refer to para 2-9.

2-7. Engine Room Access Hatch

a. General. The engine room access hatches are manually removed only when it is necessary to remove the propulsion unit(s) from the engine room.

b. Removal.

(1) Remove 76 flat head cap screws which attach each access hatch to deck.

(2) If desired, the ventilator cowl(s) may be removed from hatch. Each cowl is secured with five flat head screws.

(3) Carefully pry up edge of hatch.

CAUTION

Do not damage hatch gasket around edge of hatch.

(4) List up hatch to remove.

(5) Do not remove hatch gasket unless damaged.

c. Cleaning. Remove dirt and other foreign materials with soap and water solution.

d. Installation.

(1) Reverse procedure in *b* above.

(2) Make sure hatch gasket is seated properly without kinks.

(3) Apply anti-seizing compound to cap screw threads before installing screws.

2-8. Propulsion Units

a. General. The propulsion unit(s) must be removed from the vessel in order to remove or repair the engine oil pump, crankshaft, main bearings, pistons and connecting rods, liners, oil pan, engine base, and transmission.

b. Removal.

(1) Remove engine room access hatch (para 2-7).

(2) Disconnect battery ground lead at battery.

(3) Drain coolant from engine.

(4) Drain lubricating oil from engine and transmission.

(5) Disconnect and tag all electrical leads at engine sending units.

(6) Disconnect and tag electrical leads to hydraulic starting solenoid on inboard engine for vessels with hull numbers 8500 thru 8519, 8540 thru 8560 and 8580 thru 8618. In vessels with hull numbers 8520 thru 8539, disconnect mechanical cable from pilot house at hydraulic start release valve on inboard engine.

(7) Disconnect and tag electrical leads to alternator and regulator on inboard engines.

(8) Disconnect and tag electrical leads to electric starting motor and solenoid relay on outboard engines. For vessels with hull numbers 8520 thru 8560 and 8580 thru 8618, also disconnect and tag electrical leads to starting switch on center rear of propulsion units.

(9) Disconnect mechanical cable to quick start assembly at center rear of propulsion unit (hull numbers 8500 thru 8519 only).

(10) Turn off fuel valves on aft engine room bulkhead. Disconnect fuel lines at propulsion unit fuel strainers. Cap fuel line fitting to prevent entry of dirt into line on hulls 8540 thru 8560 and 8580 thru 8618, fuel stop valves are located in the lazarette.

(11) Disconnect and remove the water temperature thremo bulbs, the engine lubricating oil pressure gauge line, the transmission oil pressure gauge line, and the mechanical tachometer drive shaft at the engine.

(12) Remove protective cover over ramp hoist hydraulic pump. Disconnect coupling between pump and power take-off shaft.

(13) Release and remove alternator and bilge pump drive belts. The alternator and bilge pump drive belts. The alternator and regulator may be removed from the propulsion unit if desired.

(14) Disconnect raw water priming line from bilge pump(s) and raw water pump outlet line. Remove hoses between raw water piping and raw water pumps. Remove water piping as necessary to allow clearance for propulsion unit removal. On hulls 8540 thru 8560 and 8580 thru 8618, disconnect the fuel lines from the engine to fuel oil coolers.

(15) Remove bilge pump(s) and pump mounting brackets.

(16) Remove fresh water engine cooling system lines at expansion tank.

(17) Disconnect and remove engine control linkage from pilot house at propulsion unit.

(18) Remove exhaust stacks and pipes to mufflers. It may be necessary to remove asbestos covering from stacks and pipes for access to mounting flanges.

(19) Release pressure and secure hydraulic starting system. Disconnect and tag hydraulic hoses to hydraulic starter, release valve, steering pump and starting pump.

(20) Remove crankcase drain hose bracket attached to deck at inboard engine (hull no. 8500 thru 8519).

(21) Loosen hose at propeller shaft coupling. Remove the nuts, lock washers, and bolts that secure the propeller shaft flange to the transmission output shaft flange.

(22) Loosen the packing gland in the propeller shaft stuffing box and slide the propeller shaft back 6 to 8 inches to permit removal of the engine without damaging the flanges.

(23) Remove the nuts and lock washers securing the propulsion unit to the foundation.

(24) Using appropriate materials handling equipment, carefully raise the propulsion unit approximately 6 inches. Make sure all lines and cables are free before continuing to remove the propulsion unit for the boat.

WARNING

During engine removal operations instruct personnel to stay clear of engine and hoisting equipment.

(25) Move propulsion unit to a suitable work area.

(26) Replace engine base if necessary.

c. Installation. Reverse procedures in *b* above upon completion of repairs.

2-9. Winch (Ramp Hoist)

a. Removal.

(1) Lower ramp to ground if possible. If ramp cannot be lowered, be sure ramp is secured with the load binders or with the chain hoists.

(2) Remove hoisting cable from winch drum.

(3) Clean connections, disconnect hydraulic lines, and cap open ends.

(4) Remove winch mounting nuts and bolts.

(5) Remove winch from hull—total weight is 1,070 pounds.

b. Installation. Install the winch in reverse order of removal.

CHAPTER 3

REPAIR OF ENGINE AND TRANSMISSION

Section I. ENGINE ACCESSORIES

3-1. Engine Fuel System

a. This diesel engine fuel system (fig. 3-1) consists of fuel inlet and outlet manifolds, fuel injectors, fuel pipes, fuel pumps, fuel valves, fuel filters and strainers, restricted elbow, and the necessary connecting lines.

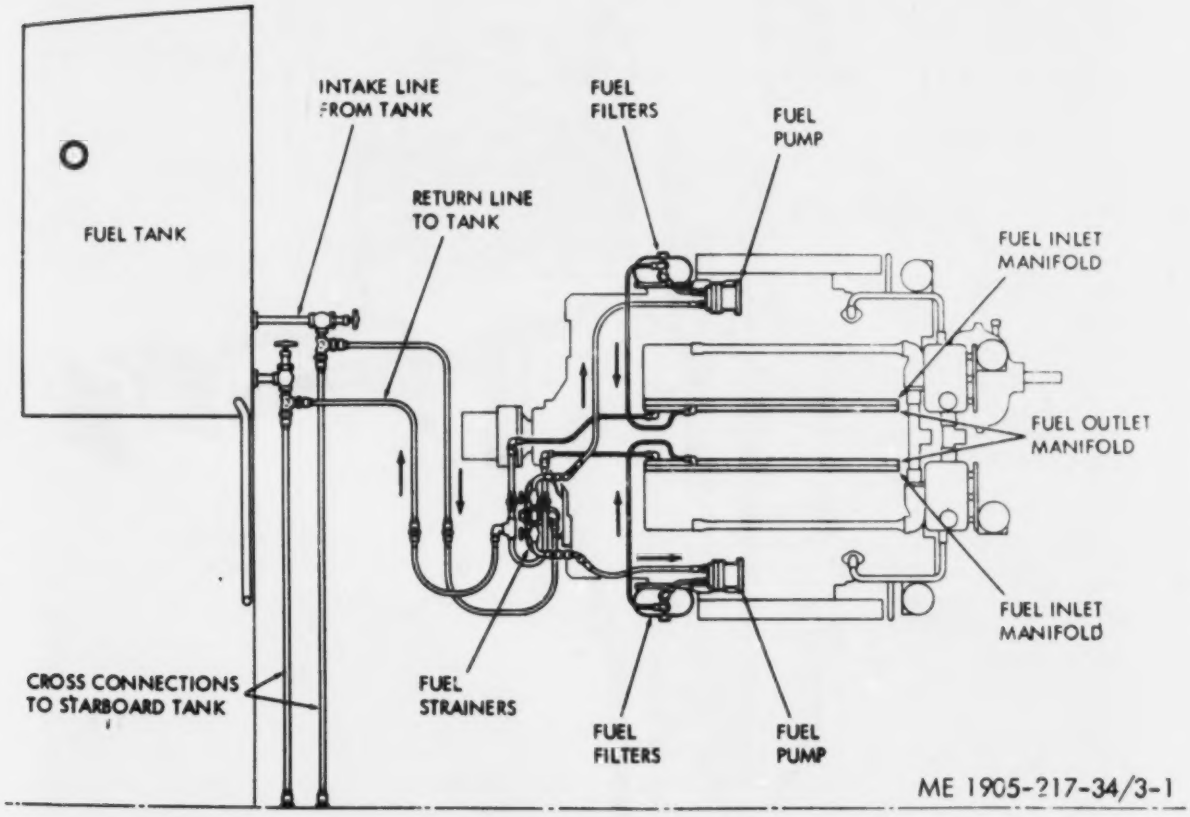

Figure 3-1. Fuel system diagram.

b. Fuel is drawn from the fuel supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filters and into the upper fuel manifold, then through fuel pipes into the inlet side of the fuel injectors. Surplus fuel returns from the outlet side of the injectors through outlet fuel pipes into the return manifold and back to the fuel tank.

3-2. Fuel Injectors

a. Description.

(1) The fuel injector (fig. 3-2) is a lightweight compact unit which enables quick easy starting on diesel fuel and permits the use of a simple open type combustion chamber. The fuel injector creates high fuel pressure required for efficient operation, it meters and injects the exact amount of fuel required to handle the load, atomizes the fuel for mixing with the air in the combustion chamber and permits continuous fuel flow.

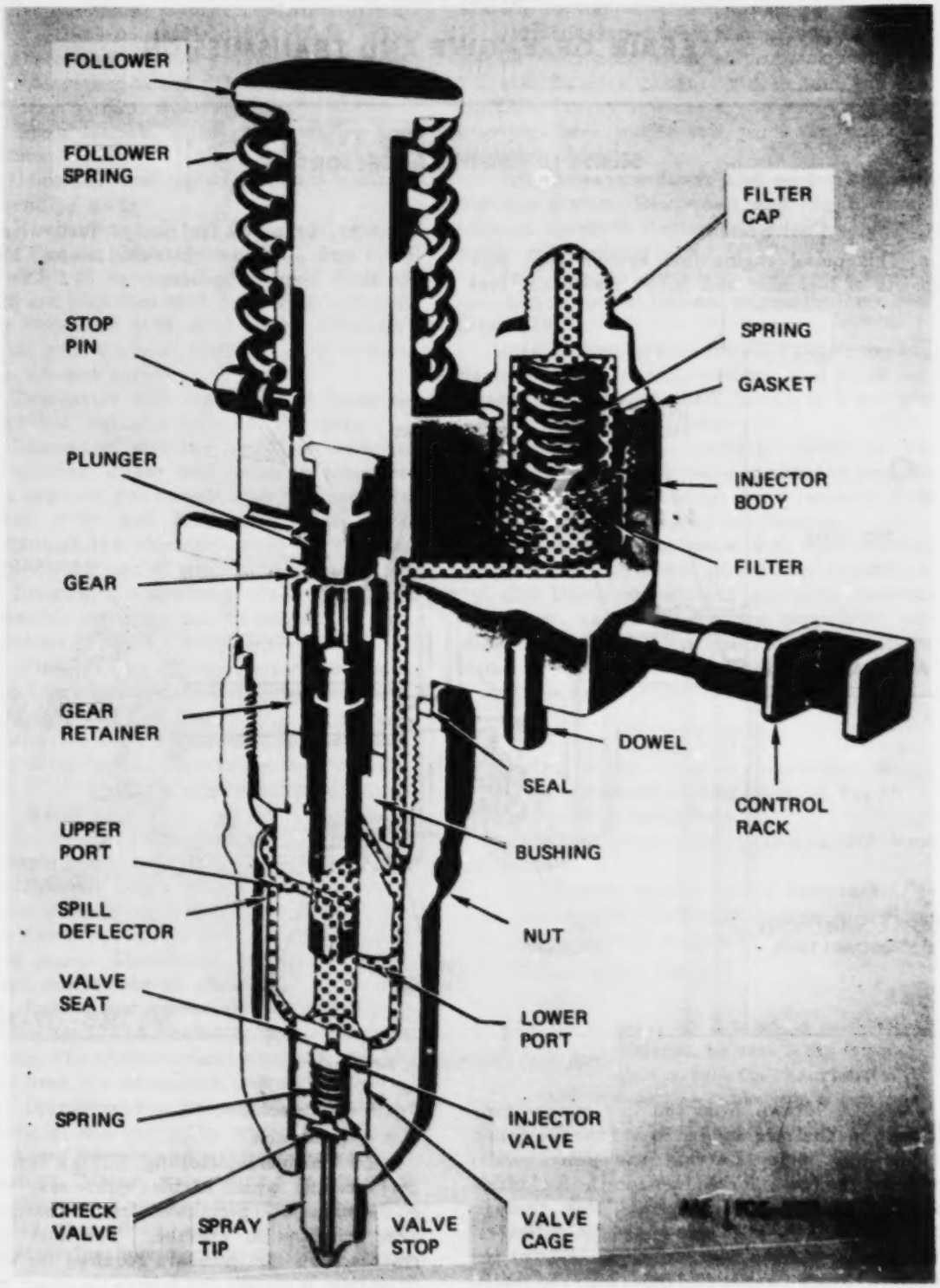

Figure 3-2. Fuel injector assembly.

(2) Figure 3-3 illustrates the fuel metering from no load to full load by rotation of the plunger in the bushing.

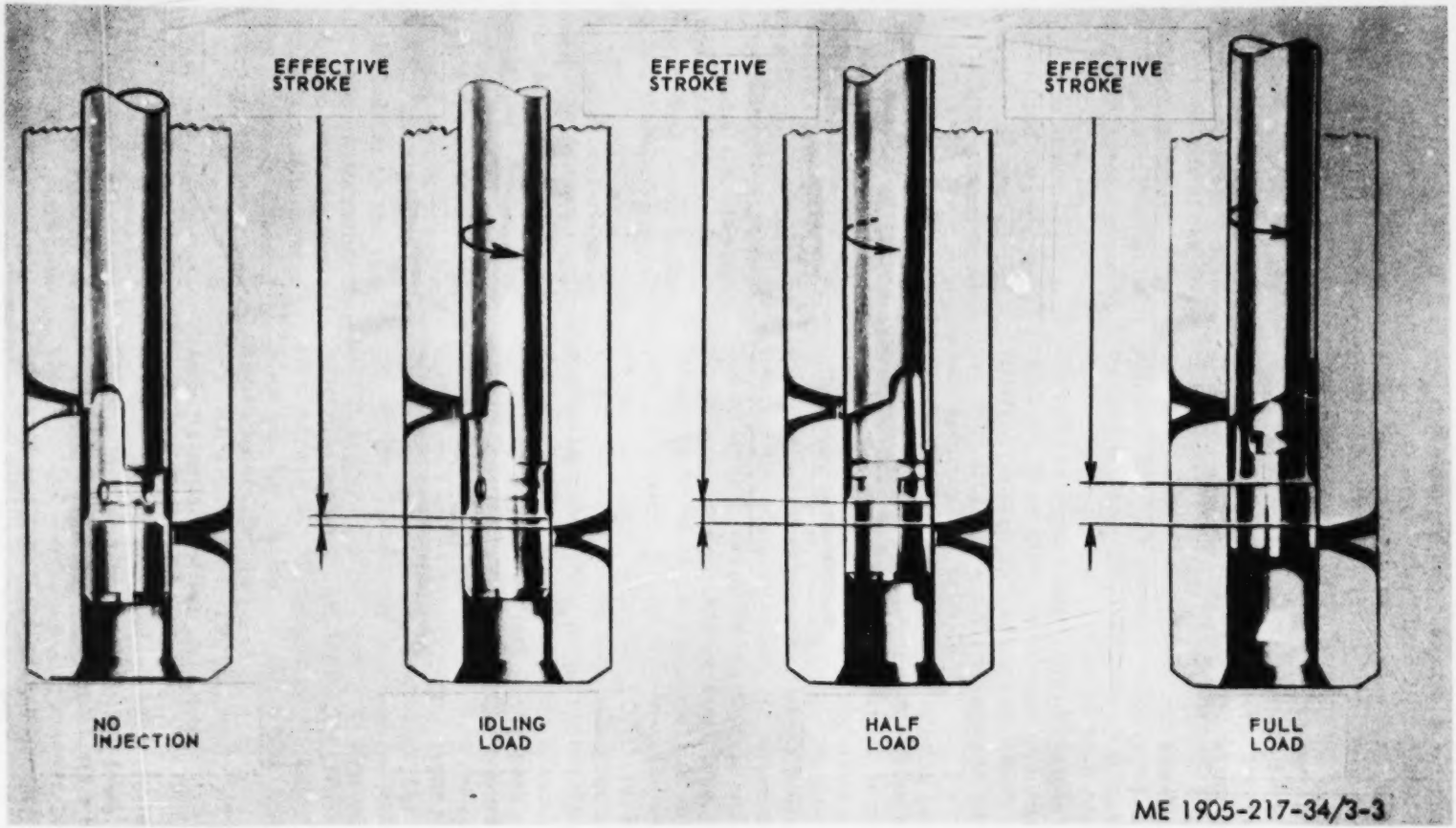

Figure 3-3. Fuel metering from no load to full load.

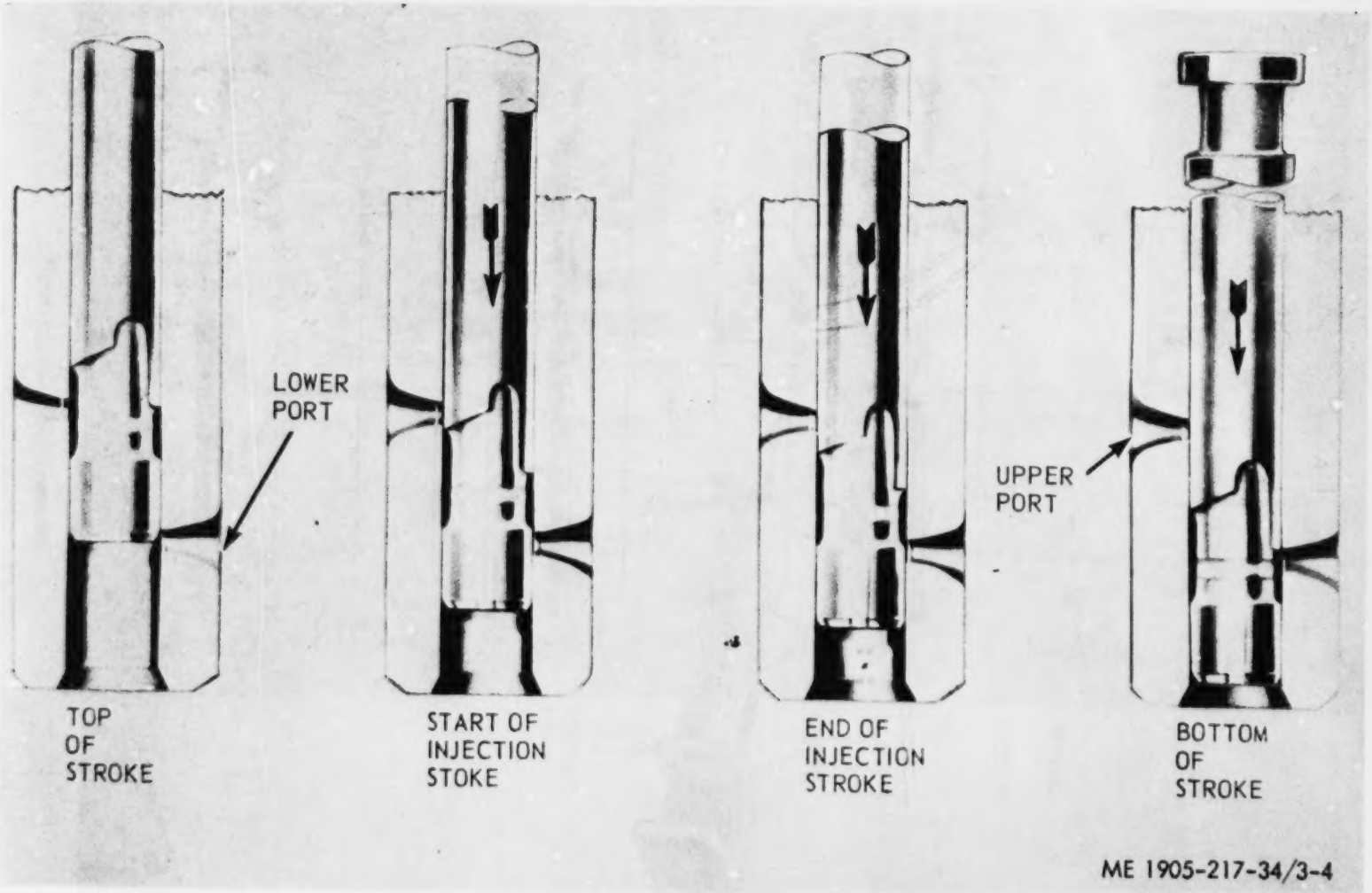

Figure 3-4. Phases of fuel injector operation through vertical travel of plunger.

(3) Figure 3-4 illustrates the phase of injector operation by the vertical travel of the injector plunger.

(4) Both the injector plunger and plunger bushing are marked with identical part numbers to properly identify them as mating parts. Therefore, if either plunger or bushing requires replacement, both must be replaced as an assembly.

(5) The fuel injector has a circular disk pressed into a recess at the front side of the injector body for identification purposes. The identification tag indicates the nominal output of the injector in millimeters. Each injector control rack (fig. 3-2) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting of all injector racks.

b. Operation.

(1) Fuel under pressure, enters the injector at the inlet side through a filter cap (fig. 3-2) and a filter element. From the filter element the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, the bore of which is open to the fuel supply in the annular chamber by two funnel-shaped ports in the plunger bushing.

(2) The motion of the injector rocker arm is transmitted to the plunger (fig. 3-2) by the follower which bears against the follower spring. In addition to the reciprocating motion, the plunger can be rotated, during operation, around its axis by the gear which meshes with the control rack. For metering the fuel, an upper helix and a lower helix are machined in the lower part of the plunger. The relation of the helicies to the two ports, changes with the rotation of the plunger.

(3) As the plunger moves downward, under pressure of the injector rocker arm, a portion of that fuel trapped under the plunger is displaced into the supply chamber through the lower port until the port is closed off by the lower end of the plunger. A portion of the fuel trapped below the plunger is then forced up through a central passage into the plunger fuel metering recess and into the supply chamber through the upper port until the port is closed off by the upper helix of the plunger. With the upper and lower ports both closed off, the remaining fuel under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

(4) When sufficient pressure is built up, the injector valve is lifted off its seat and the fuel is forced through small orifices in the spray tip (fig. 3-2) and atomized into the combustion chamber.

(5) A check valve (fig. 3-2), mounted in the spray tip, prevents air leakage from the combustion chamber into the fuel injector in case the injector valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its original position by the injector follower spring. Figure 3-4 shows the various phases of injector operation by the vertical travel of the injector plunger.

(6) On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports, the constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector and also, effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate fuel metering.

(7) The fuel injector outlet opening through which the excess fuel oil returns to the fuel return passage and then back to the fuel tank, is directly adjacent to the inlet opening and contains a filter element exactly the same as that in the inlet side.

(8) Changing the position of the helices, by rotating the plunger, retards of advances the closing of the ports and the beginning or ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. Figure 3-3 shows the various plunger positions from NO LOAD to FULL LOAD. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all the fuel is forced back into the supply chamber so no injection of fuel takes place. With the control rack pushed in (full injection), the upper port is closed shortly after the lower port has been covered thus producing a maximum effective stroke and maximum injection. From this no injection position to full injection position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

c. Removal. Refer to TM 55-1905-217-12 (para 4-28) for removal of the fuel injector.

d. Fuel Injector Testing.

(1) Injector rack and plunger movement. Check to see if plunger (fig. 3-2) works freely in its bushing by placing the injector against a bench (fig. 3-5) and depressing the follower to the bottom of its stroke while moving the rack back and forth. Failure to produce a free rack indicates the internal parts of the injector are dirty or damaged.

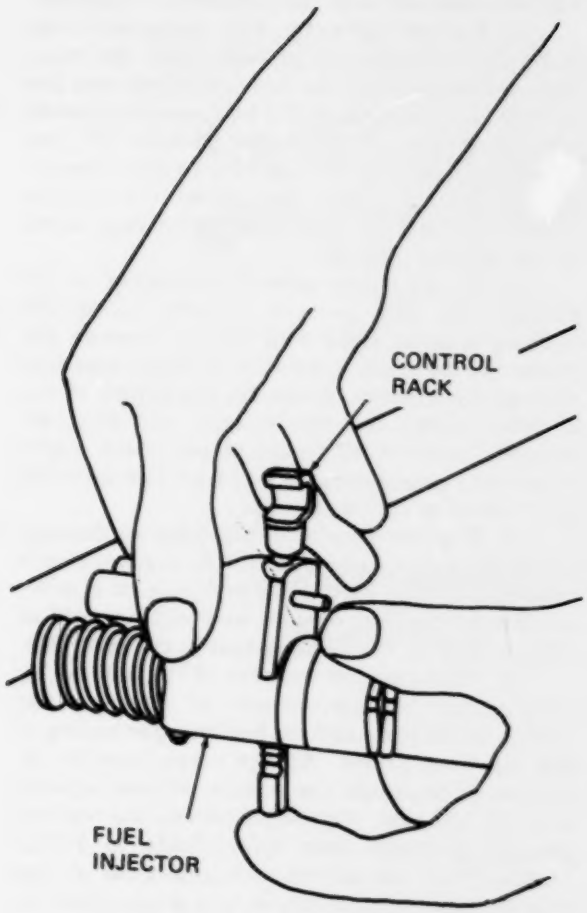

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Figure 3-5. Checking fuel injector rack for freeness.

WARNING

The injector must always be held in such a way as to prevent any fuel spray from penetrating a person's skin. Fuel oil which enters the blood stream may cause a serious infection.

(2) *Valve opening (pop-pressure) test.*

(a) Place the fuel injector in the testing and popping fixture (fig. 3-6), with dowel on the underside of the injector located in the proper slot of the adaptor plate. Position injector support plate and popping handle support to the proper height.

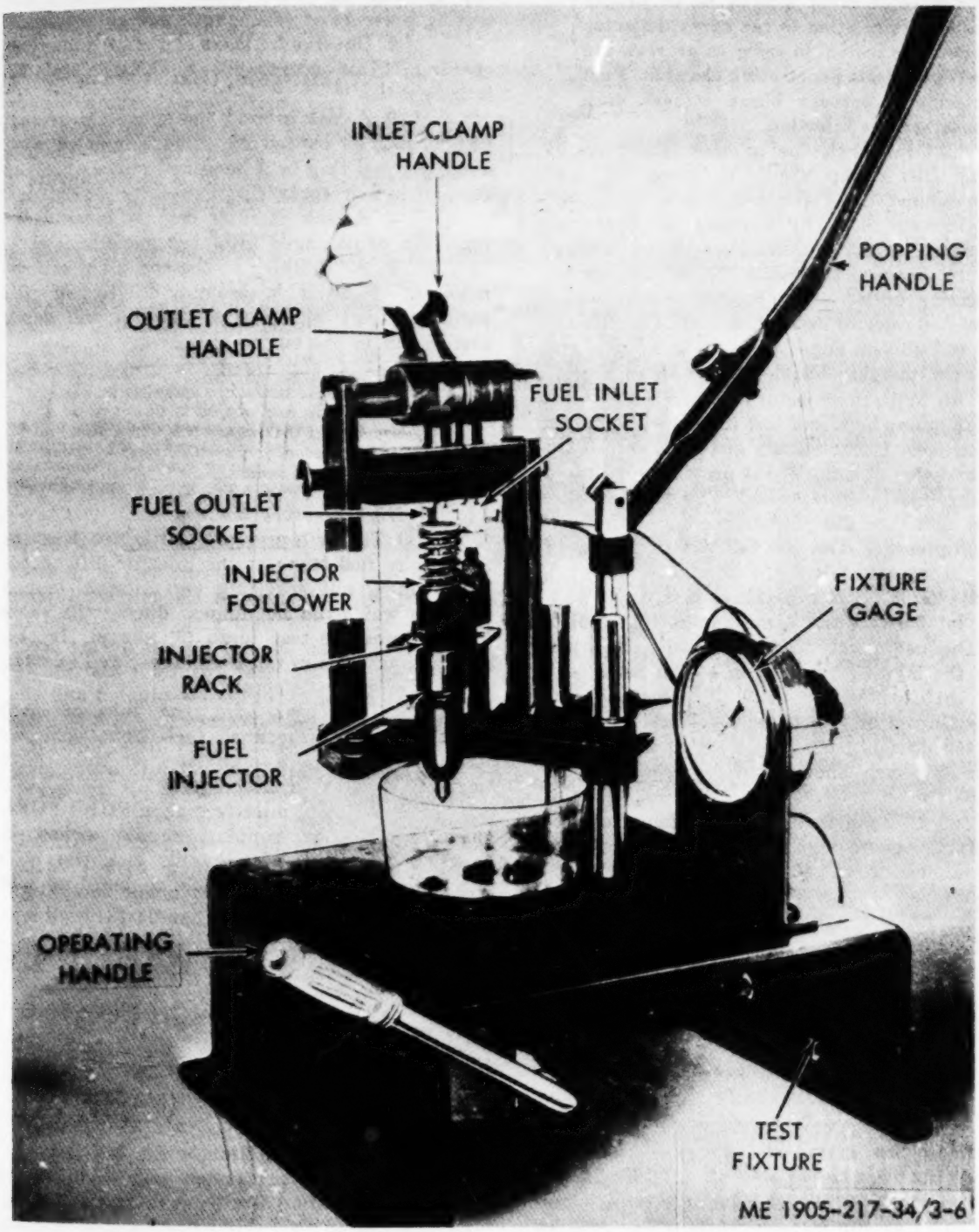

Figure 3-6. Fuel injector in testing and popping fixture, installation.

NOTE

Before using the injector tester, or when refilling it with fuel oil, disconnect the tube of the gage and pump the handle until all the air is expelled from the system. Then connect the tube to the gage.

WARNING

The injector must always be in proper position in relation to the spray deflector before it is tested, in order to prevent the fuel spray from penetrating the skin. Fuel entering a persons blood stream may cause serious infection.

(b) Connect the fuel injector to fuel line by rotating inlet clamp handle to move fuel inlet socket against the fuel injector inlet filler cap. Purge injector of air by stroking the operating handle until clear fuel flows from the outlet cap.

(c) Connect the outlet line to fuel injector by rotating outlet clamp handle to seal socket against fuel injector outlet filter cap. Operate the tester to build up slight pressure in system and stroke the popping handle two or three times.

(d) With the injector rack in FULL FUEL position, pump handle of test fixture with smooth even strokes. Check fixture gage and record the injector valve opening (pop) pressure indicated with the injector sprays fuel. The pop pressure should be 450 to 850 pounds per square inch. If the pop pressure does not fall within the above range, repair or replace the injector.

(3) *Valve holding pressure test.*

(a) Operate the pump handle (fig. 3-6) to bring the fuel injector pressure up to a point just below the injector pop pressure (450 psi).

(b) Close the fuel shutoff valve and note the pressure drop. The time for a pressure drop from 450 pounds per square inch to 250 pounds per square inch should not be less than 40 seconds.

(c) If the injector pressure drops from 450 pounds per square inch to 250 pounds per square inch in less than 40 seconds, perform the following:

1. Thoroughly dry the injector with compressed air. Open the test fixture fuel valve and operate the pump handle to maintain the testing pressure of 450 pounds per square inch.

2. Observe for leaks at the injector rack opening. If this occurs a poor bushing to body fit is indicated.

3. A leak around the spray tip or seal ring usually is caused by a loose injector nut, damaged seal ring or a hardened surface on the injector nut or spray tip.

4. A leak at filter cap indicates loose filter cap or damaged filter cap gasket.

5. A "dribble" at the spray tip orifices indicates a leaky valve assembly due to damaged surface or dirt. Leakage at this tip will cause preignition in the engine.

NOTE

A drop or two of fuel at the spray tip is only an indication of the fuel trapped in the spray tip at the beginning of the test and is not detrimental as long as the pressure drop specified (para (c) above) is not less than 40 seconds.

(4) *High pressure test.*

(a) The high pressure test is necessary to detect any fuel leaks at the injector filter caps, body plugs, nut seal ring and internal lapped surfaces which did not appear during the valve holding pressure test (para (3) above). It also indicates whether or not the plunger and bushing clearances are satisfactory.

(b) Thoroughly dry the injector with compressed air. Check all fuel connections for leaks and tighten if necessary. If leaks have occured, dry the injector again.

(c) With the injector rack in FULL FUEL position and the popping handle locked in position by means of a handle lock (fig. 3-7) stroke pump operating handle to build up and maintain pressure.

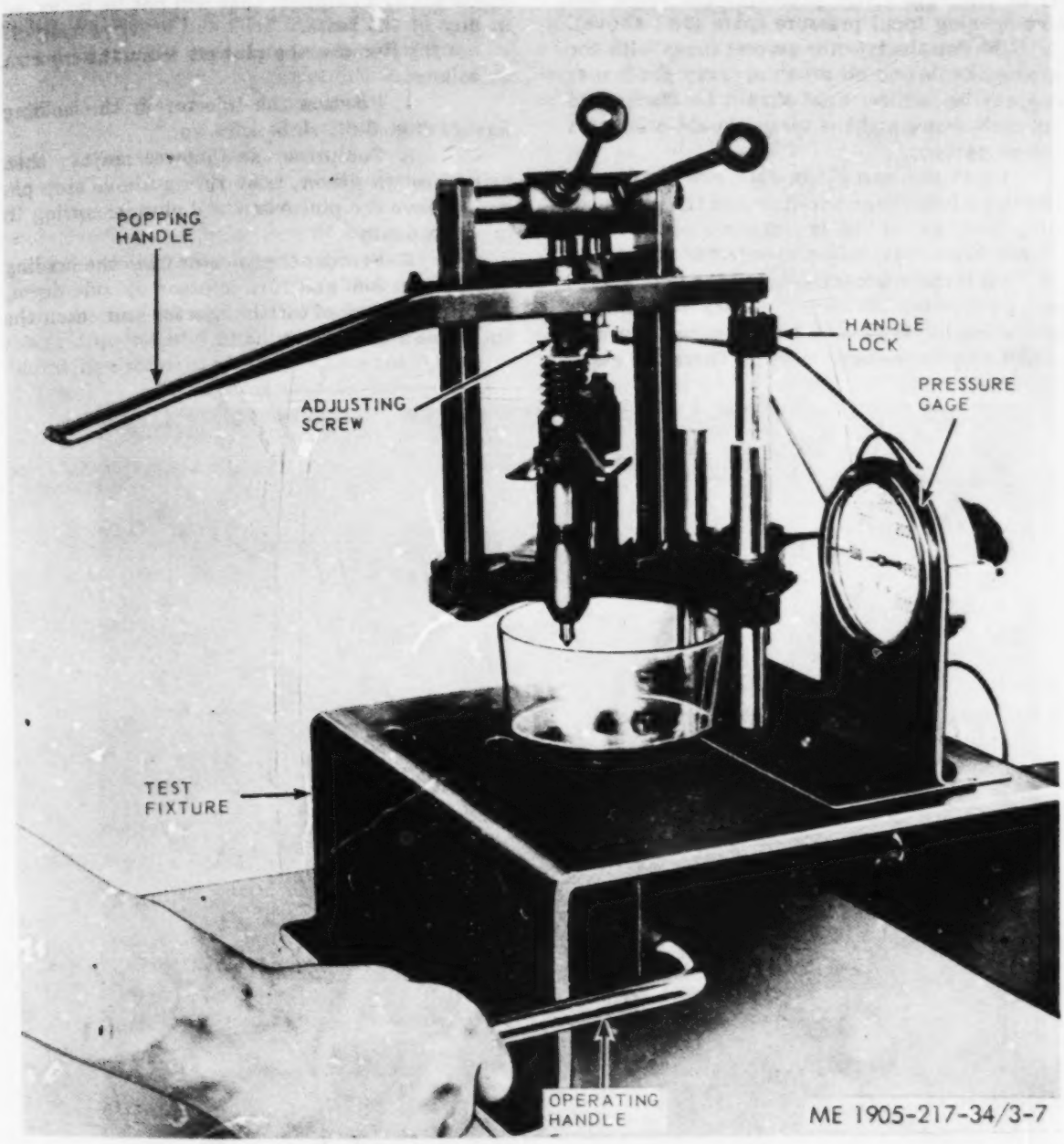

Figure 3-7. Fuel injector high pressure test.

(d) Use the adjusting screw in the injector tester handle and depress the injector plunger just far enough to close both ports in the injector bushing. The point at which both ports are closed easily noticed because the injector spray will decrease appreciably and the pressure will rise.

(e) If there is excessive clearance between the plunger and the bushing, the operator will be unable to pump up pressure beyond normal valve opening (pop) pressure. Replacement of the plunger and bushing is then necessary.

(f) Pump the test fixture and maintain a pressure of 1600 to 2000 pounds per square inch and inspect for leaks at the injector filter cap gaskets, body plugs, injector nut seal ring area, and injector rack hole.

CAUTION

Do not permit the pressure in the test fixture to equal or exceed the capacity of the pressure gage.

(5) *Spray pattern test.*

(a) With the injector in the FULL FUEL

position, stroke the pump operating handle (fig. 3-7) to maintain a fuel pressure just below the valve opening (pop) pressure (para (3*a*) above).

(b) Pop the injector several times with the popping handle and observe the spray pattern at the spray tip orifice. Fuel should be discharged from each orifice and the spray should produce a uniform pattern.

(c) If the spray tip does not produce a uniform pattern, clean the orifice of the spray tip during overhaul of the injector.

(6) *Visual inspection of injector plunger.*

(a) If the injector passes all the above tests (para (1) through (6) visually check the plunger under a magnifying glass, for excessive wear or a possible chip on the bottom helix. There is a small area on the bottom helix and lower portion of the upper helix, if chipped, that will not be indicated in any of the tests.

(b) Remove the plunger from the injector as follows:

1. Position the injector in the holding fixture (fig. 3-8), right side up.

2. Compress the follower spring, then using a screw driver, raise spring above stop pin and remove the pin. Allow the plunger spring to raise gradually.

3. Remove the injector from the holding fixture (fig. 3-8) and turn injector up side down, to prevent entry of dirt in injector and catch the spring and plunger in hand.

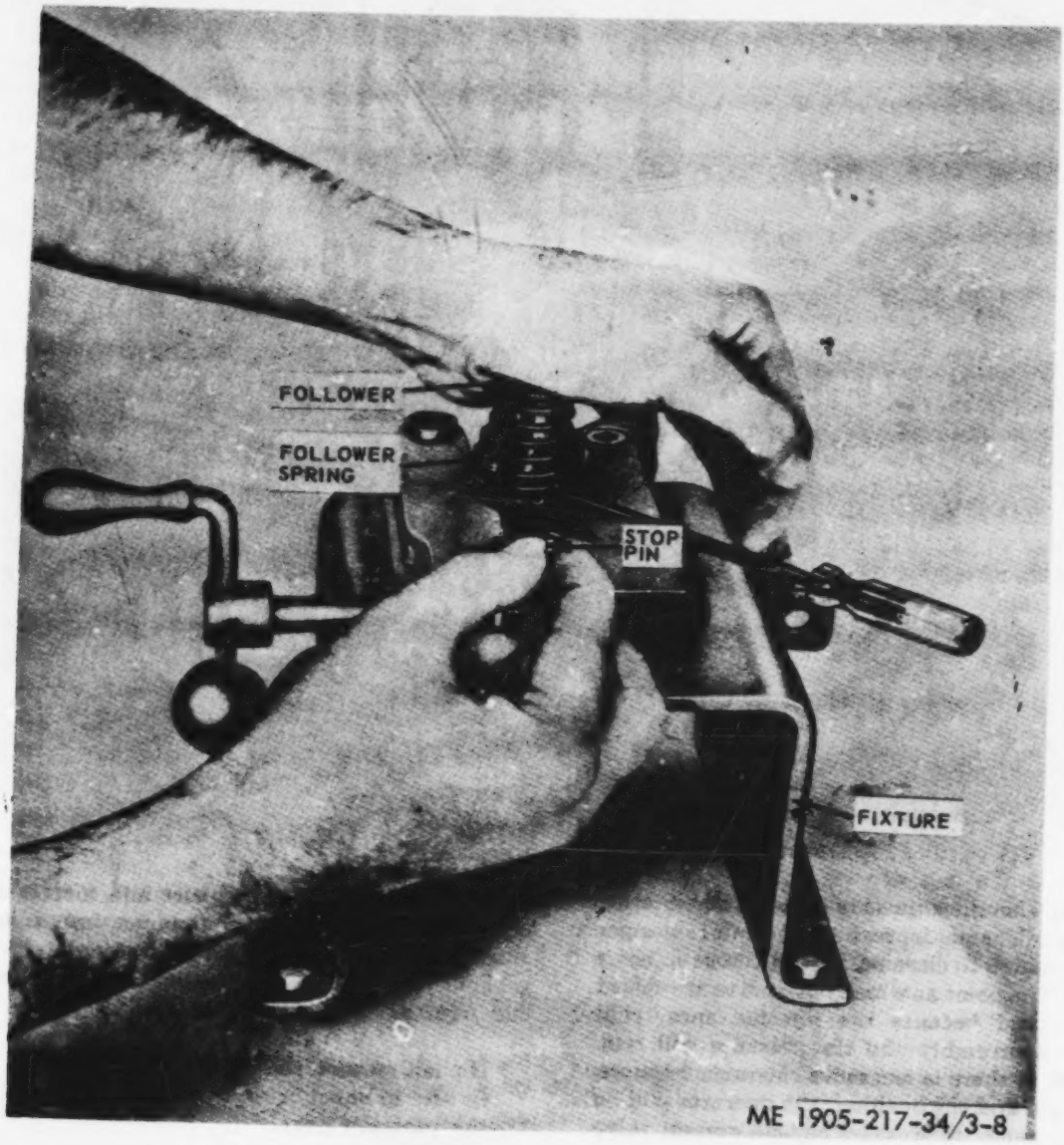

Figure 3-8. Fuel injector follower stop pin, removal.

4. Inspect the plunger. If chipped, replace the plunger and bushing after the fuel output test is performed. Plunger (B, fig. 3-9), illustrates a chipped plunger at the helix.

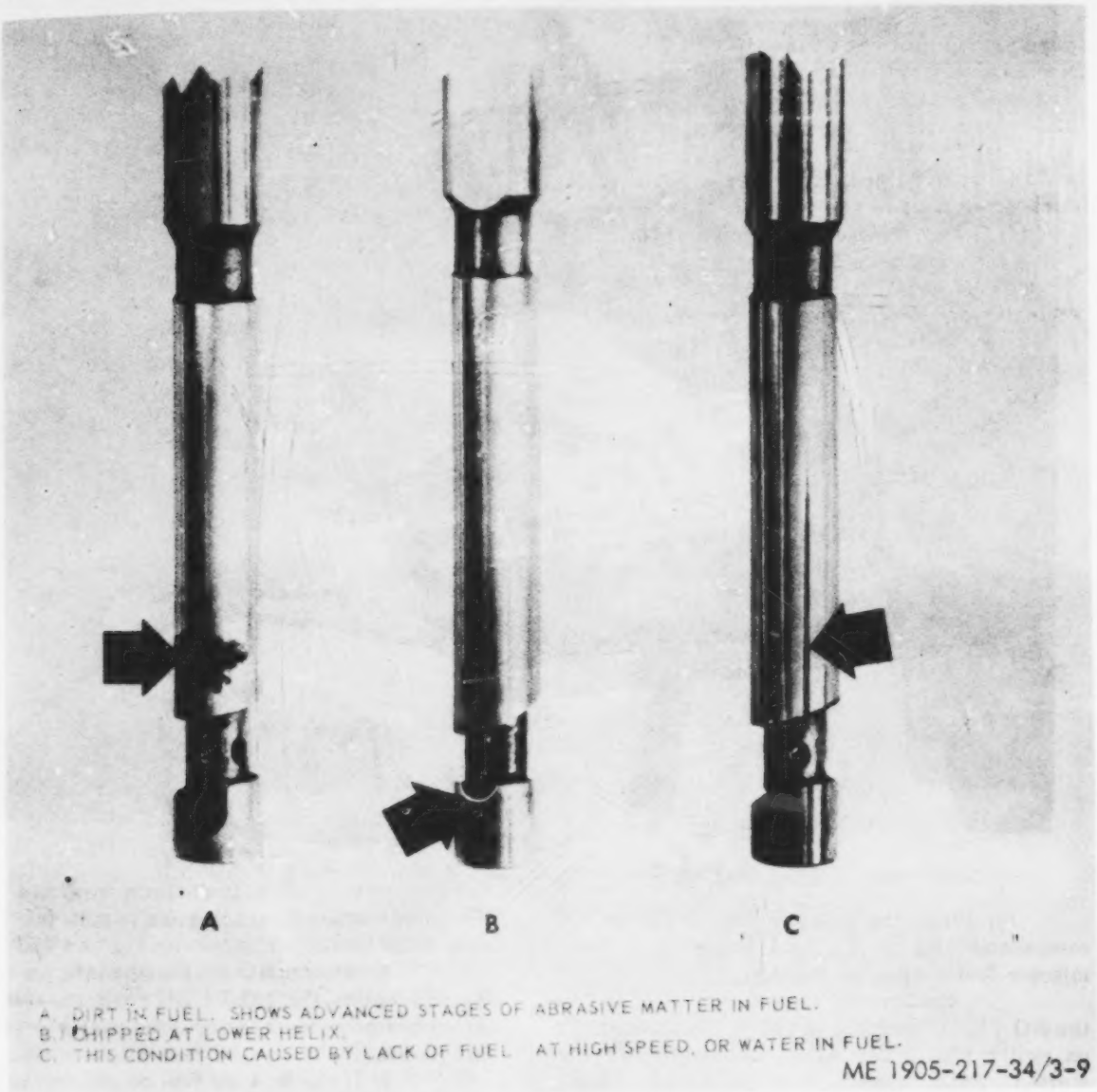
A
B
C
A. DIRT IN FUEL. SHOWS ADVANCED STAGES OF ABRASIVE MATTER IN FUEL.
B. CHIPPED AT LOWER HELIX.
C. THIS CONDITION CAUSED BY LACK OF FUEL AT HIGH SPEED, OR WATER IN FUEL.
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Figure 3-9. Defective fuel injector plungers.

(7) ***Fuel output test.***

(a) Set the comparator (fig. 3-10) at 1000 strokes.

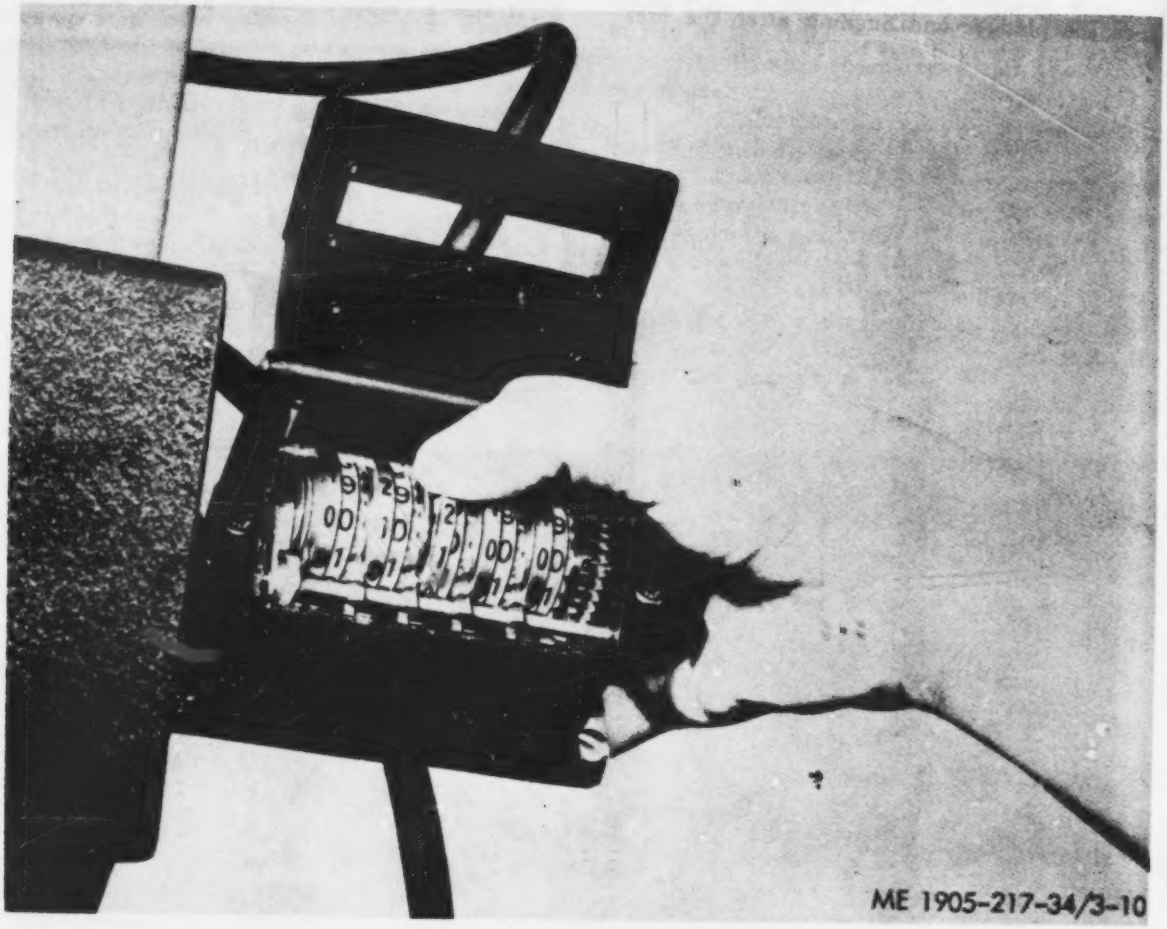


Figure 3-10. Setting comparator stroke counter.

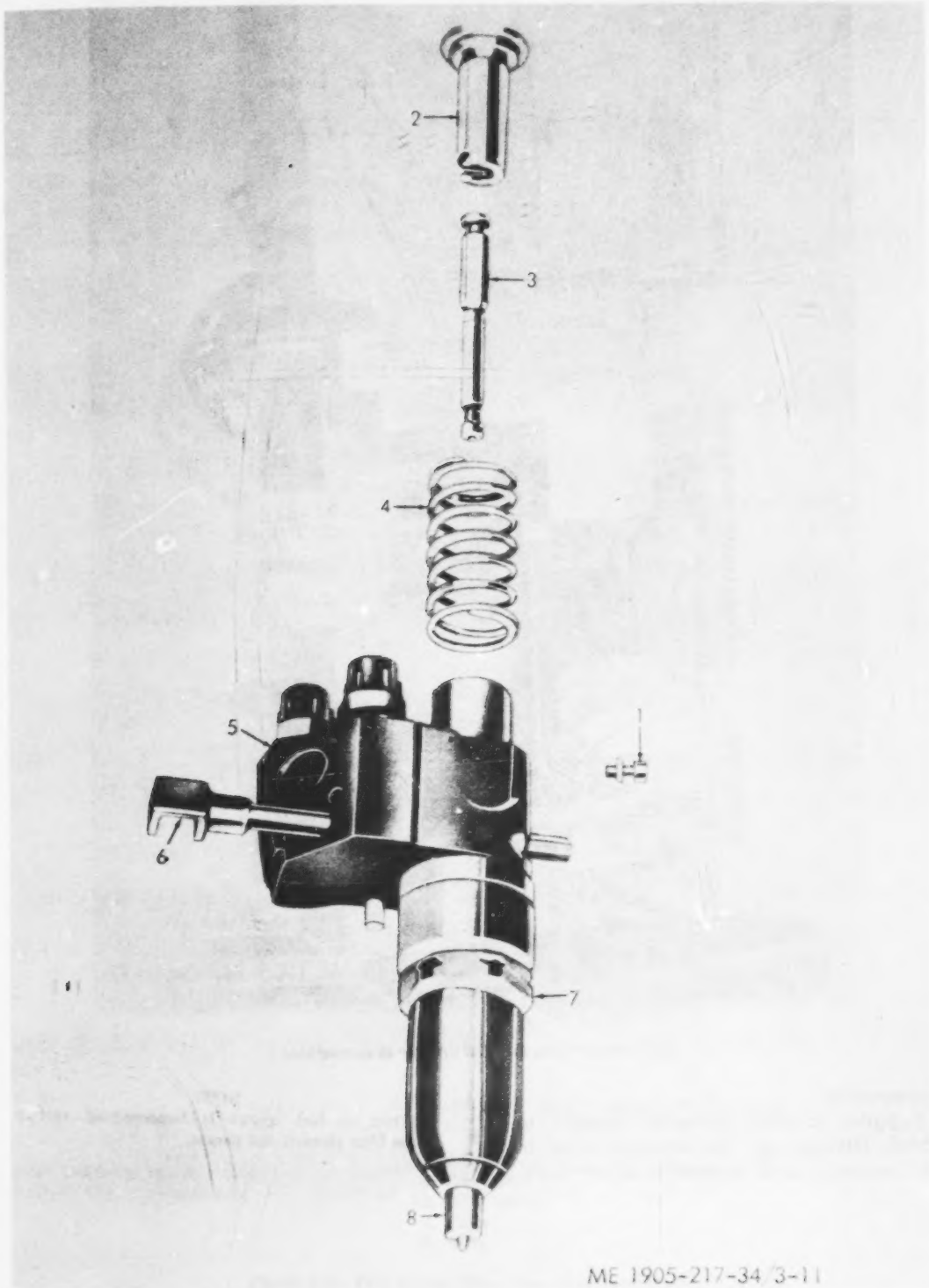
(b) Place the injector (fig. 3-11) in the comparator (fig. 3-12), seal firmly and check injector fuel output as follows:

1. Pull control rack (6, fig. 3-11) out to the NO FUEL position and start the comparator on switch (fig. 3-12). After the comparator has started, push injector rack to FULL FUEL position.

2. Run the injector for 30 seconds to purge all air that may be in system. Press fuel flow start bottom to start flow of fuel into vial. The comparator will automatically stop fuel flow after 1000 strokes.

3. After fuel stops flowing into vial, pull the rack out to the NO FUEL position, turn off the comparator, reset the counter and observe the vial reading.

4. If the injector fuel output in the vial does not fall within a minimum of 30cc (cubic centimeters) or maximum of 36cc, the injector is defective and must be repaired.



1. Stop pin
2. Follower
3. Plunger
4. Follower spring
5. Body
6. Control rack
7. Nut
8. Spray tip

Figure 3-11. Injector follower, spring and plunger, removal and installation.

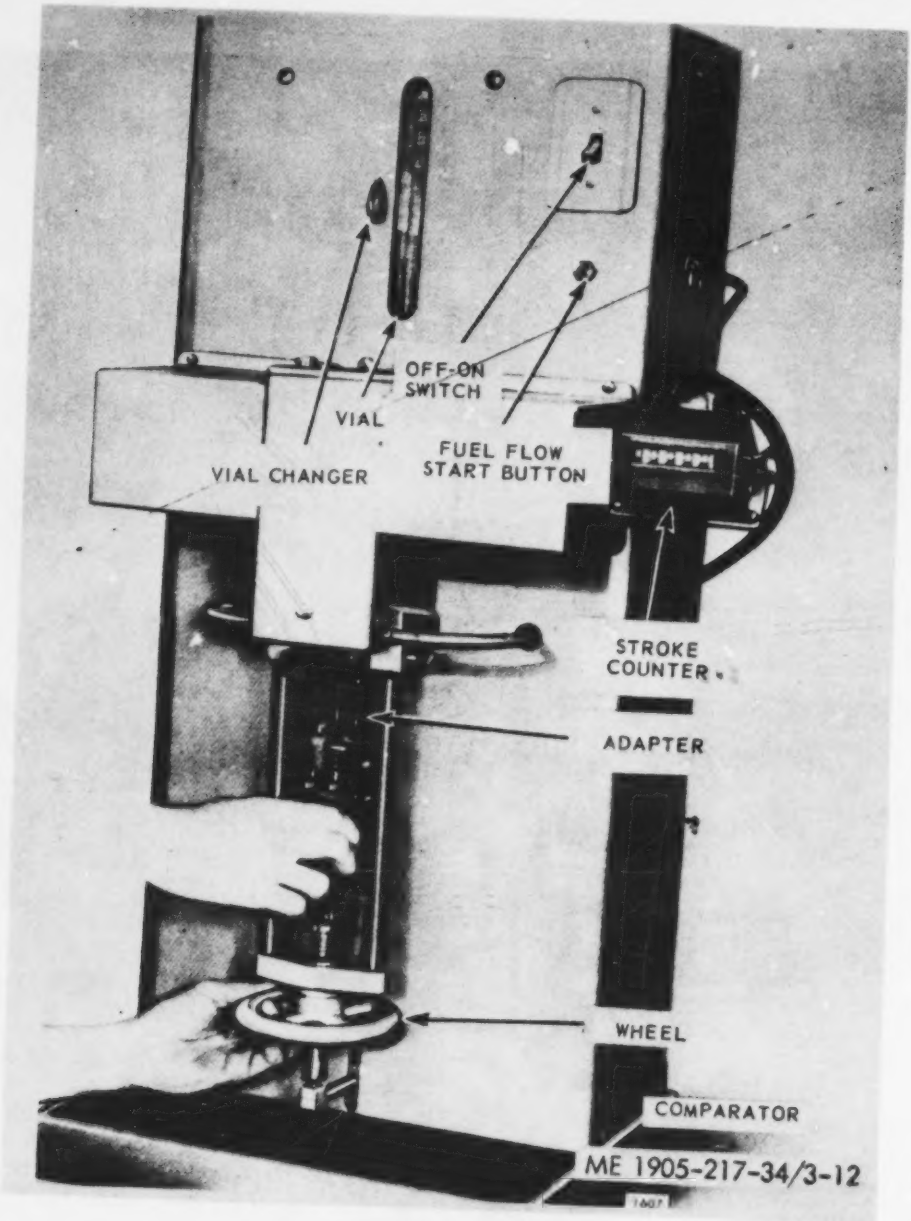


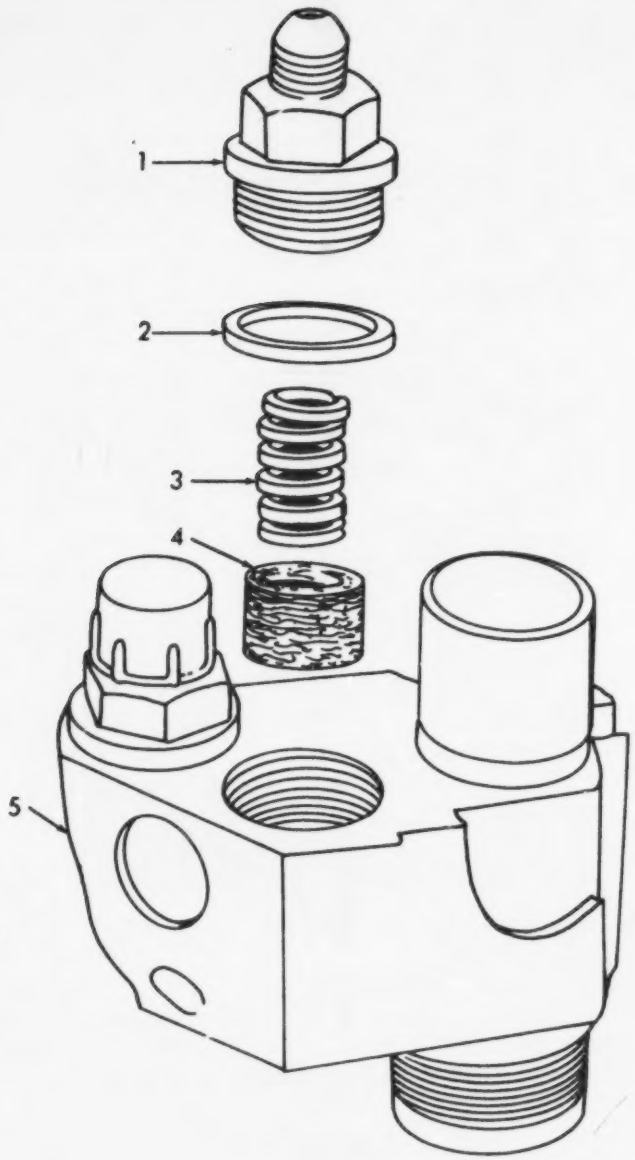
Figure 3-12. Installing fuel injector in comparator.

e. Disassembly.

(1) Support injector assembly upright in fixture tool. Disassemble the injector filter in numerical sequence as illustrated in figure 3-13.

NOTE

When the fuel injector is desassembled, replace the filter element and gasket.



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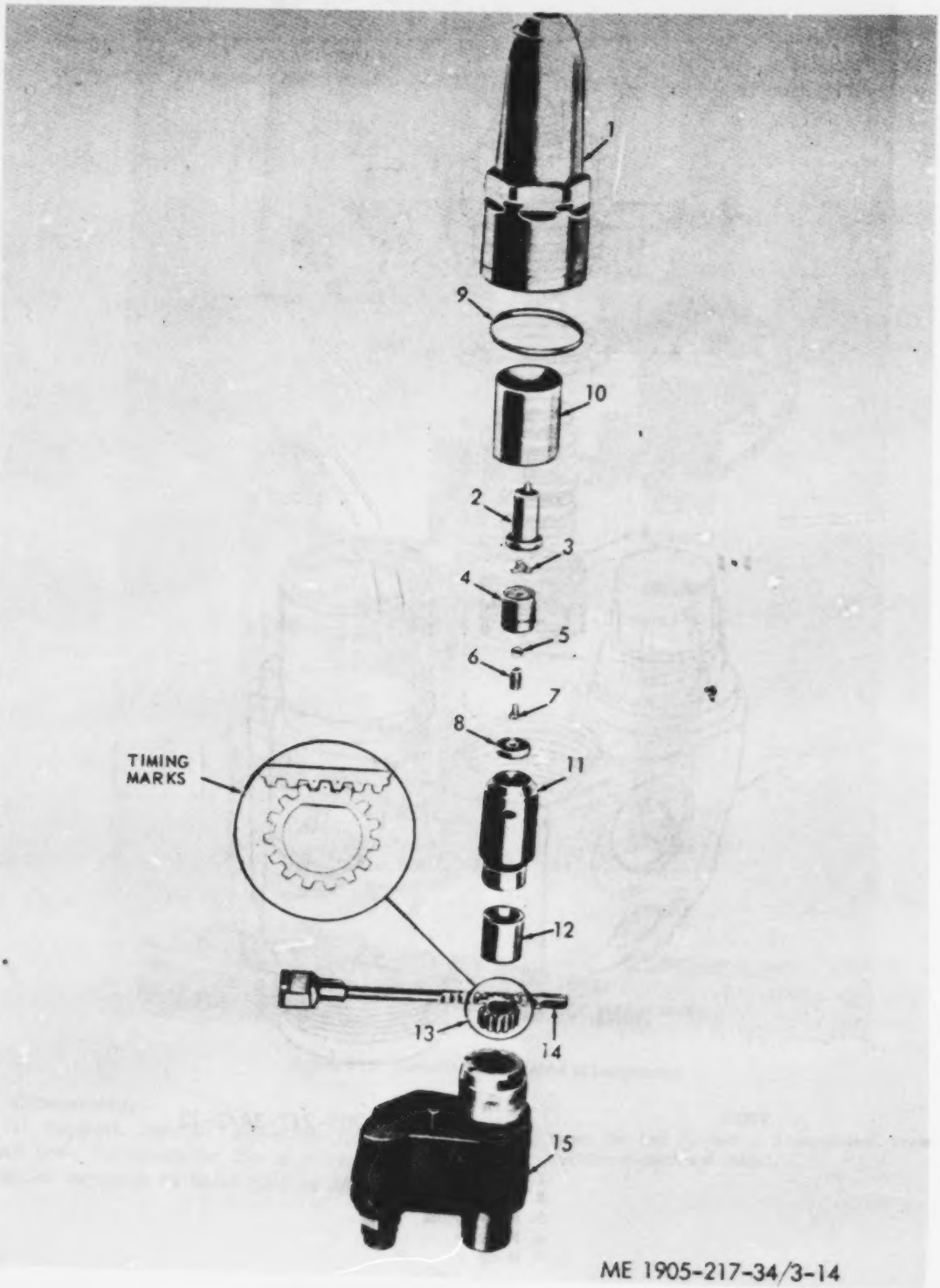
1. Filter cap
2. Cap gasket
3. Filter spring
4. Filter
5. Body

Figure 3-13. Fuel injector filter, removal and installation.

(2) Refer to figure 3-8 and remove injector follower stop pin.

(3) Refer to figure 3-11 and remove injector follower, spring and plunger.

(4) Reverse the injector in the fixture, and disassemble using a deep socket, loosen nut (1, fig. 3-14) on the injector body (15) the injector rack, gear, spray tip and valve assembly components in numerical sequence as illustrated in figure 3-14.



1. Nut
2. Spray tip
3. Check valve
4. Check valve gage
5. Valve stop
6. Valve spring
7. Injector valve
8. Valve seat
9. Seal ring
10. Spill deflector
11. Bushing
12. Gear retainer
13. Rack gear
14. Control rack
15. Injector body

Figure 3-14. Injector rack, gear, spray tip and valve assembly components, removal and installation.

(5) Lift the injector nut straight up by hand, being careful not to dislodge the spray tip and valve parts off bushing and place in a clean receptacle.

(6) If the spray tip can not be pushed from the nut with the fingers remove as shown in figure 3-15.

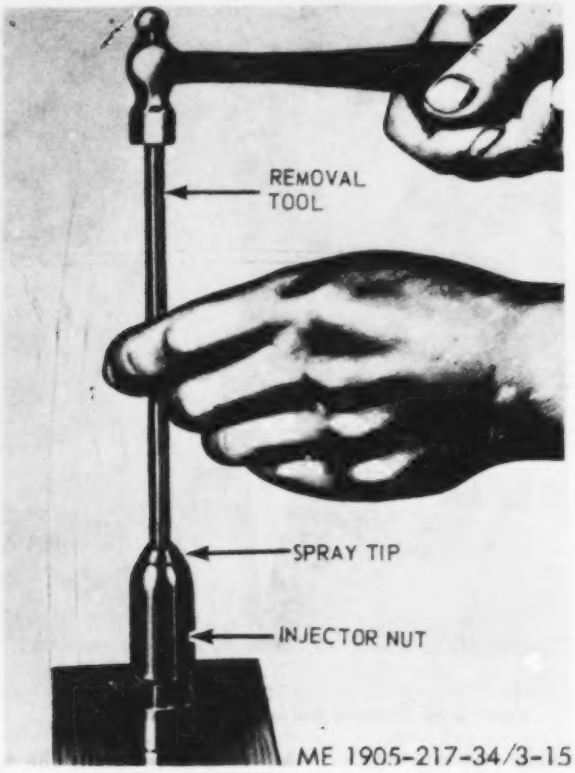


Figure 3-15. Removing spray tip from fuel injector nut.

f. Cleaning and Inspection.

(1) Wash all parts with clean fuel oil or cleaning solvent and dry with clean, filtered compressed air. Do not use waste or rags. Clean all passages, drilled holes and slots in all injector parts.

(2) Remove carbon deposits from spray tip with reamer (fig. 3-16).

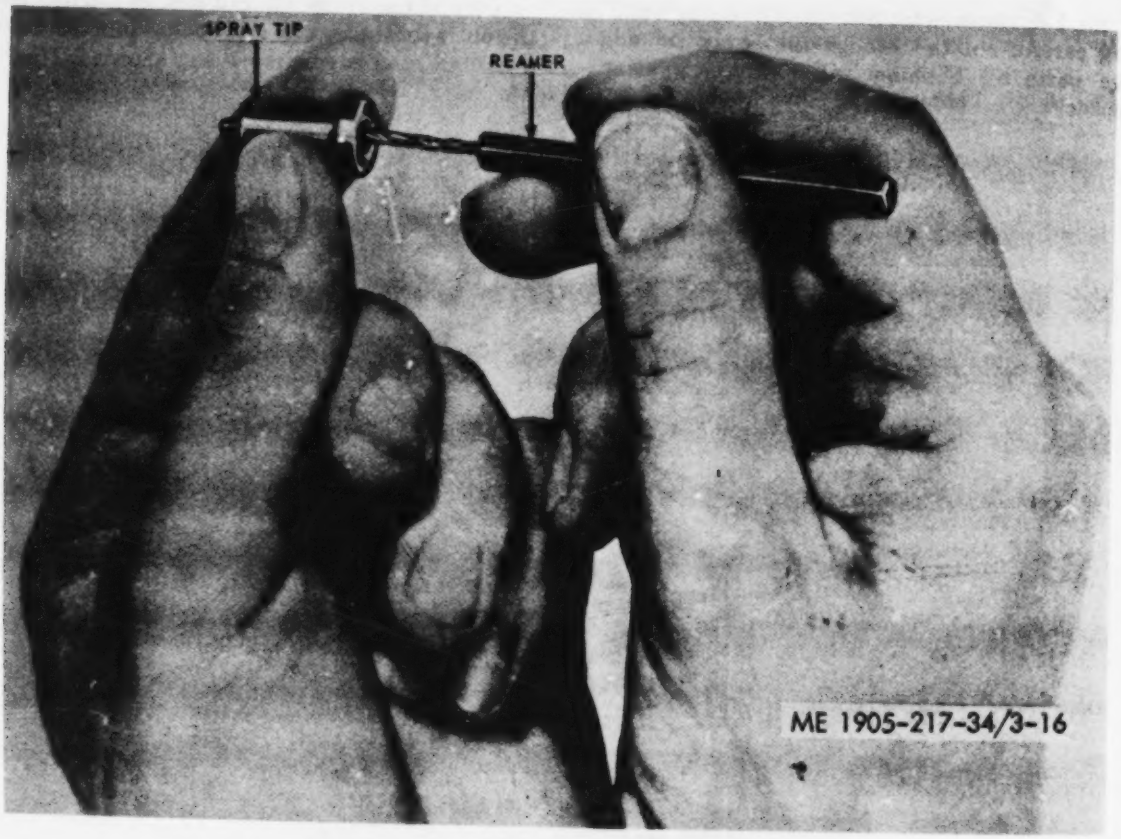


Figure 3-16. Reaming fuel injector spray tip.

(3) Clean the spray tip orifices with pin vice and proper size spray tip cleaning wire (fig. 3-17). Use wire J-21461 to clean 0.006 inch diameter holes. Before using the wire, hone the wire, end until it is smooth and free of burs, allow the wire to extend 1/8 inch from tool.

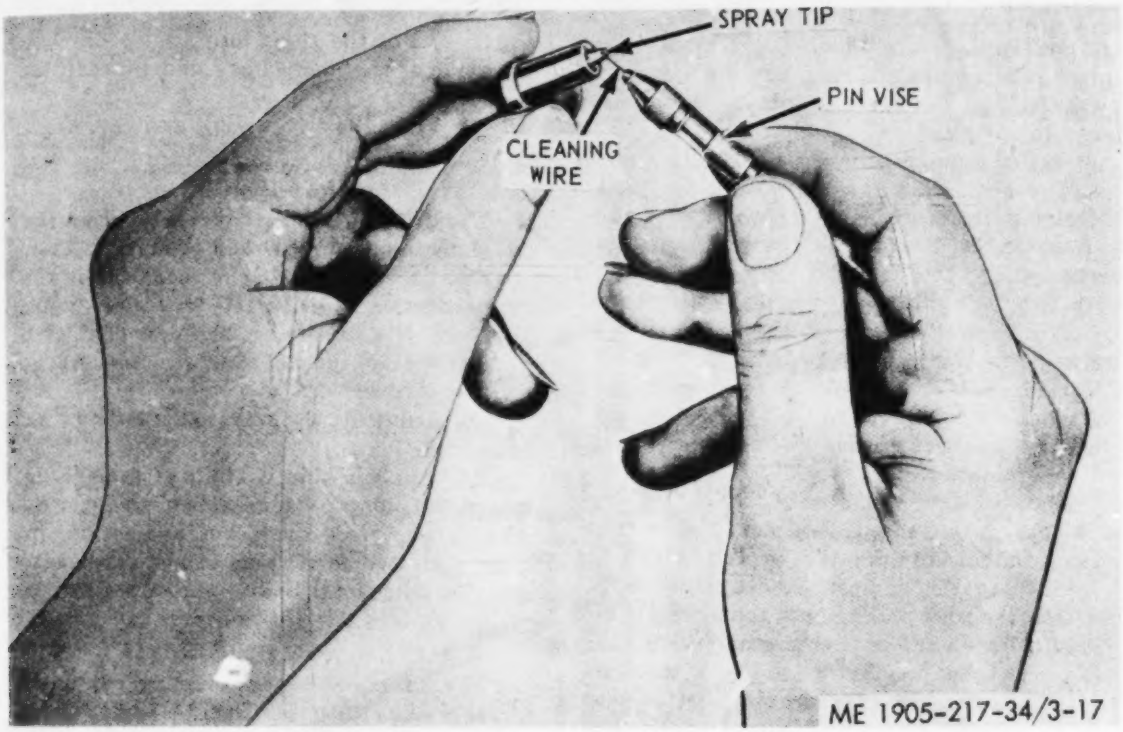


Figure 3-17. Cleaning fuel injector spray tip orifices.

(4) Clean and brush all passages in the injector body. Refer to figure 3-18 and ream injector spray tip seat. Carefully insert reamer into the injector nut. Turn reamer in a clockwise direction to remove carbon deposits. Use care in reaming to prevent removing any metal or burring the spray tip seat. Then wash in clean fuel oil and dry with compressed air.

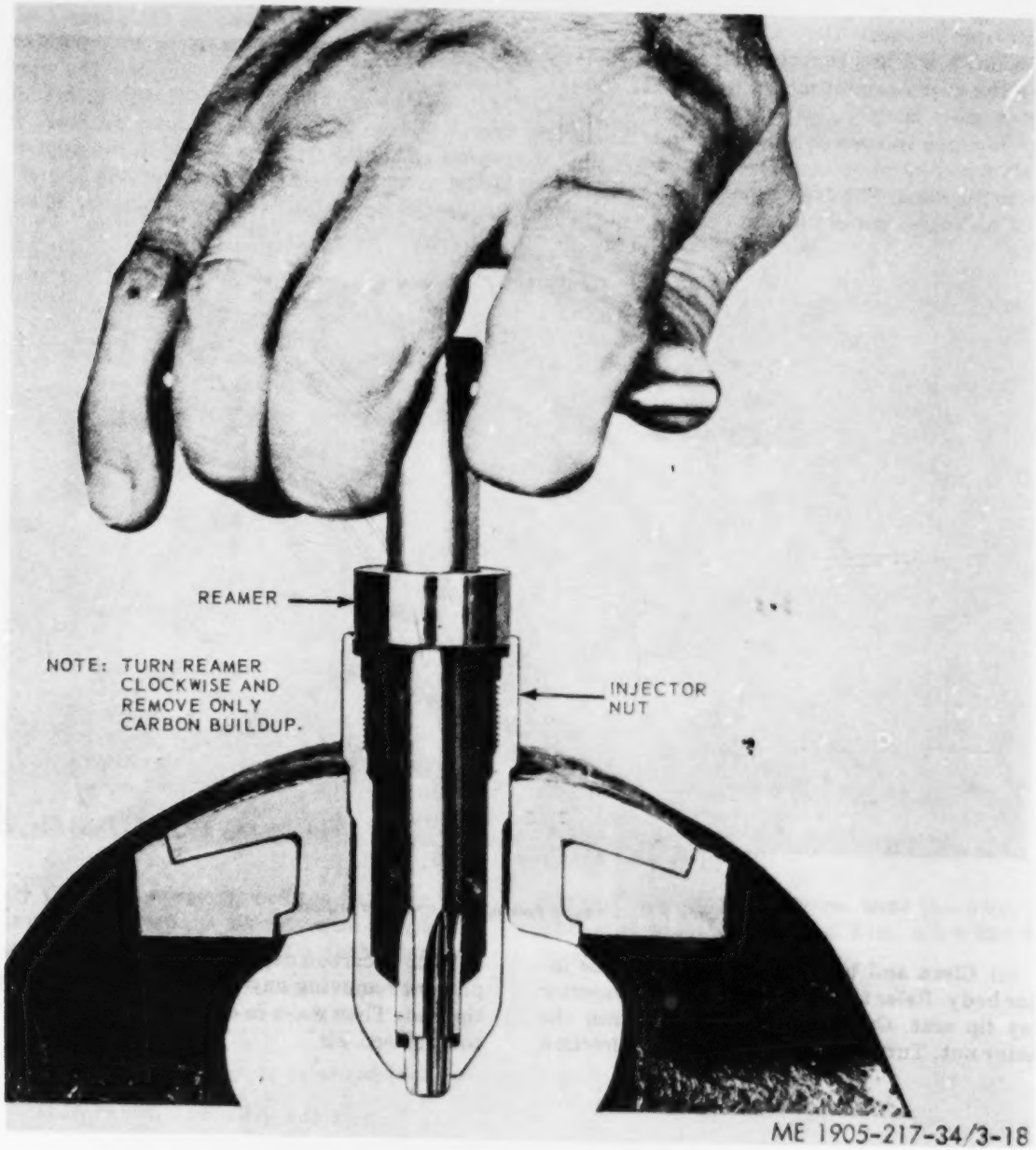


Figure 3-18. Cleaning fuel injector nut spray tip seat.

(5) When handling the injector plunger, do not touch finished plunger surfaces with the fingers. Wash plunger and bushing with clean fuel oil and dry with filtered compressed air. Final clean with soft tissue paper. Keep plunger and bushing together as they are mated parts. After cleaning, keep parts of each injector in separate clean containers.

(6) Inspect the teeth on the control rack and control rack gear for excessive wear or damage. Inspect both ends of spill deflector for sharp edges or burs which could create burs on the injector body nut. Remove burs with a medium stone.

(7) Inspect follower spring for defects and proper tension. The spring has a free length of approximately 1.668 inches. Replace spring when a load of less than 48 lbs will compress it to 1.028 in length.

(8) Check the seal ring area in the injector body and the surface with contacts the injector bushing for damage, if necessary, lap the surface (para (g) below). A faulty sealing surface at this point will result in a high fuel consumption and contamination of the lubricating oil.

(9) Inspect the injector plunger for scoring errosion, chipping or wear at helix. Check plunger for sharp edges on that portion which rides in the gear. Remove sharp edges with 500 grit stone. Wash plunger after stoning. Inspect the plunger bushing for damage. Slip plunger straight into bushing and check for free movement. Replace defective plunger and bushing as an assembly, if either one is damaged. Injector plungers cannot be reworked to change the output. Grinding will destroy the hardened case of the helix and will result in seizure or scoring of the plunger.

(10) Inspect the spray tip seating surface in the injector nut for excessive nicks, burs or hard spots. Reseat surface or replace nut.

(11) Inspect the injector valve spring for wear or damage. Replace defective spring.

(12) Inspect the sealing surfaces of the spray tip and valve parts as indicated by arrows, (fig. 3-19). Inspect all surfaces with a magnifying glass for even the slightest imperfections will prevent the injector from operating properly. Check for burs, nicks, errosion, cracks, chipping and excessive wear. Inspect the spray tip for enlarged orifices. Replace damaged or worn parts. Refer to paragraph *g* below for lapping injector parts.

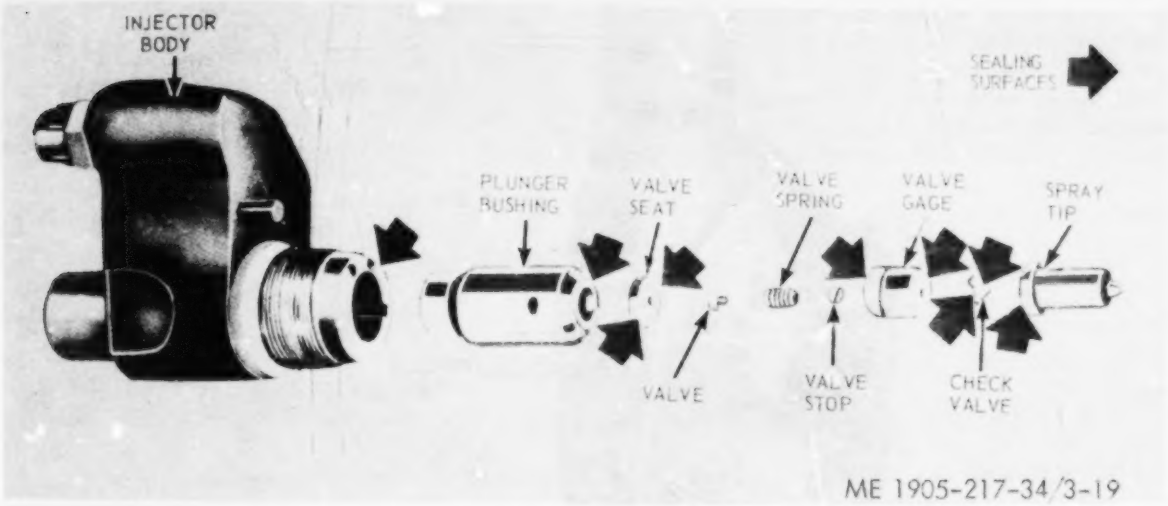


Figure 3-19. Fuel injector sealing surfaces which may require lapping.

g. Lapping Injector Parts.

(1) Clean the lapping block with filtered moisture free compressed air and spread a good quality, 600 grit dry lapping powder on one side of lapping blocks.

CAUTION

Do not use cloth or other material for this purpose.

(2) Place the part to be lapped flat on the bock and, using a figure eight motion, move it bick and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.

(3) After each four or five passes, clean the lapping powder from the part by drawing it across a dean piece of tissue placed on a flat surface and inspect the part. Do not lap excessively.

(4) When the lapped part is flat, wash it in cleaning solvent and dry with filtered compressed air. Place the part on a second block and repeat the lapping procedure (paras *g* (1) through (3) above for a fine finish.

(5) Wash and dry the part again and repeat the above lapping operation WITHOUT lapping powder. This dry lapping will give the part a mirror finish required for perfect sealing.

(6) Only the edge of the hole in crown valve seat contacts the valve, this edge must be nearly perfect, must be a true circle and present an unbroken surface. Examine the edge of the hole under a magnifying glass for chipping or cracks. If the edge of hole shows irregularities, the hole must be lapped.

(7) Position a drill motor in a vice and mount the lapping tool in the motor (fig. 3-20) and place a small amount of oil mixture on the tool.

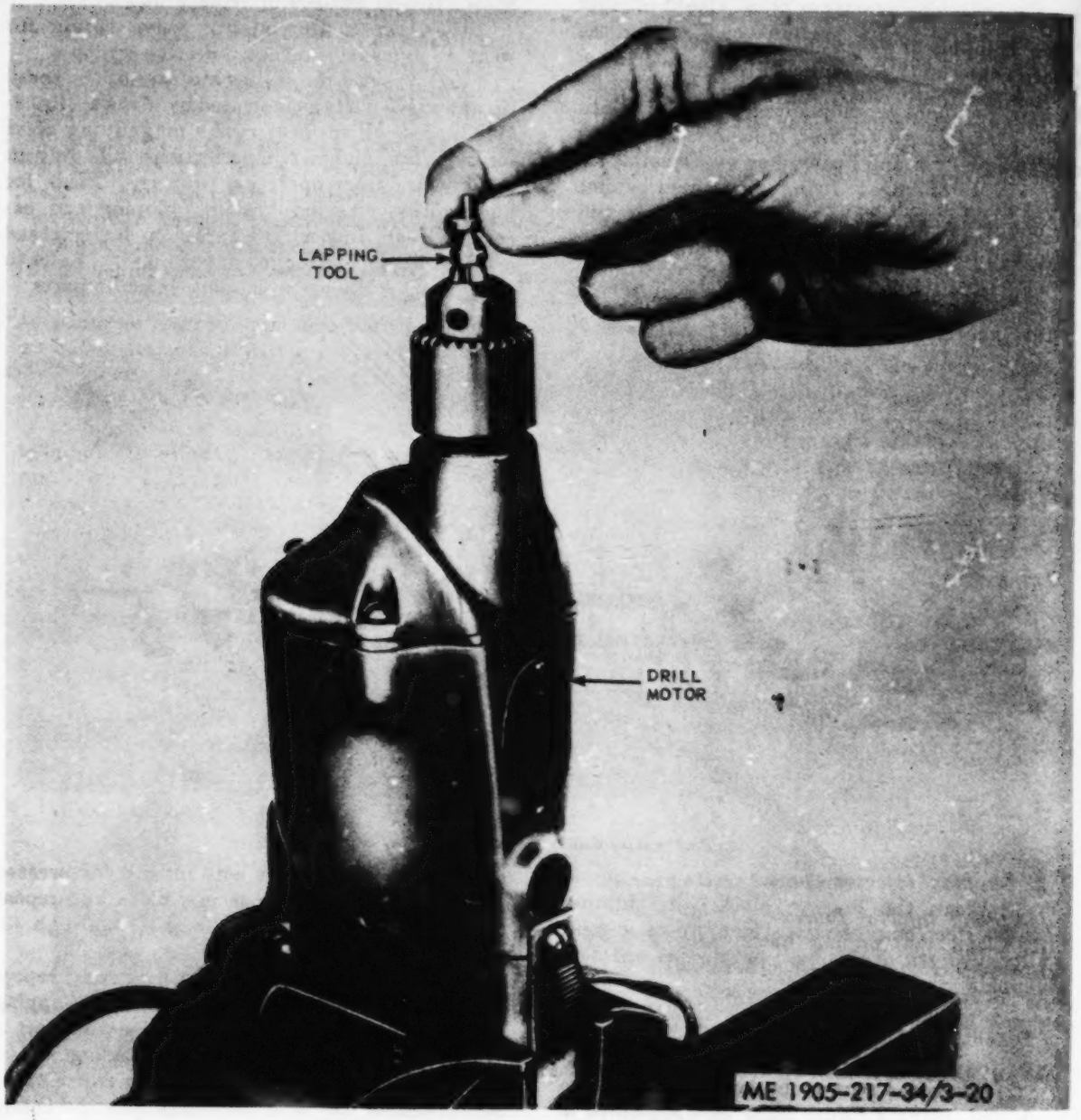


Figure 3-20. Lapping edge of hole in fuel injector valve seat.

(8) Place the valve seat over the pilot of the tool and start the drill. Holding the valve with the fingers, touch it lightly against the rotating lapping tool to produce a uniform seat at the hole. After lapping the edge of the hole in this manner, flat lap the face of the seat lightly, then clean and examine the width of the edge. Width of the chamfer produced at the edge of the hole should be within .002 to 1005 inch. A width in excess of these limits will lower the pop pressure of the injector.

(9) Wash all injector parts that were lapped in clean fuel oil and dry with filtered compressed air. Clean the inside of the bushing by wrapping clean tissue around tool and rotate in and out through the bushing.

NOTE

Due to the possiblity of parts being burred or nicked during handling, lap all sealing surfaces of the new parts except for crown valve.

h. Reassembly.

(1) *Filter assembly*

(a) Use new filters and gaskets, refer to figure 3-13 and reassemble the injector filter components.

NOTE

The fuel filters have a dimple at one end. When assembling the filters always install the filter with the dimple down.

(b) Lubricate the filter cap threads and torque to 65 to 70 ft-lb. Install shipping caps on all openings to prevent any dirt particles from entering injector.

(2) *Rack and gear assembly.*

(a) Refer to figure 3-14 and install the rack and clear assembly.

(b) Hold the injector body bottom end up and slide the rack through the injector body. Observe the two marred teeth when locking into the bore of the gear from the bottom side of the injector body. Slide the gear into the proper position with the rack.

(3) *Injector valve and related parts.*

(a) Refer to figures 3-2 and 3-14 and install the injector valve and related parts.

(b) Lubricate the threads on injector body, carefully pilot the valve nut over the spray tip and check valve assembly, install the nut making sure the valve assembly does not shift.

(c) Do not tighten the nut at this time.

(4) *Plunger and follower assembly.*

(a) Position the injector body in the fixture (spray tip down). Refer to figure 3-11 and install the injector follower, spring and plunger.

(b) Push the control rack all the way in then, insert the free end of the plunger in the injector body.

(c) Refer to figure 3-21 and place the stop pin on the injector body so the bottom coil of the follower spring rests on the narrow flange of the pin. Then, aline the slot in the follower with the stop pin hole in the injector body. Next, aline the flat side of the plunger with the flat in the gear. Press down on the follower and at the same time press the stop pin into position. When in place the spring will hold the stop pin in position.

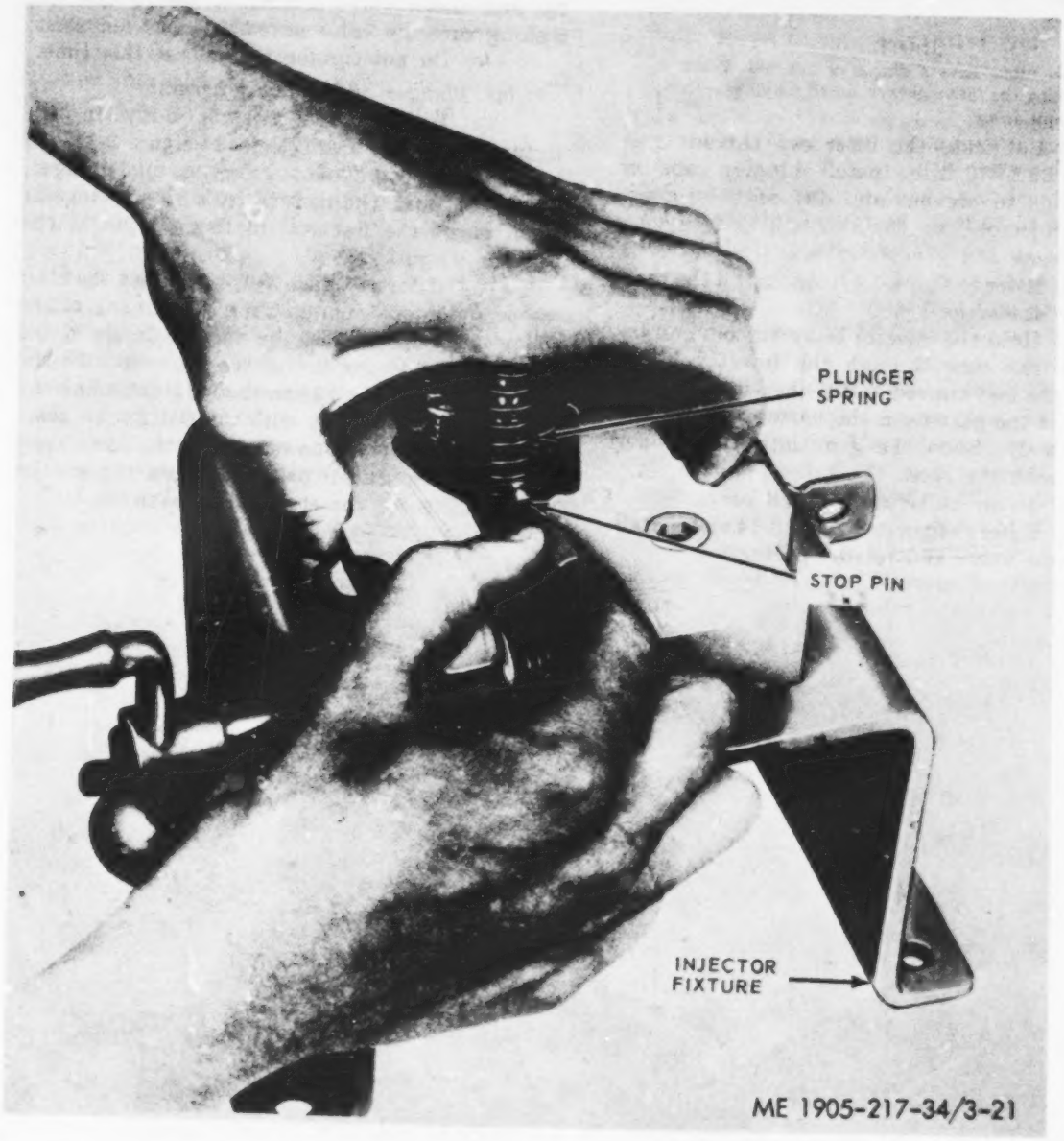


Figure 3-21. Installing fuel injector follower stop pin.

(d) Invert the injector assembly in the fixture and tighten the injector nut (fig. 3-14) to 55 to 65 ft-lb torque.

(e) Spray tip concentricity check.

1. Position the injector in the concentricity gage (fig. 3-22) and adjust the dial indicator to zero.

Figure 3-22. Checking fuel injector spray tip concentricity.

2. Rotate the injector 360 ° and note the total runout as indicated on the dial. If it exceeds .008 inch, remove the injector from the gage. Then, loosen the injector nut, center the spray tip and tighten the nut to 55-65 ft-lb torque.

3. Recheck the spray tip concentricity.

If after several attempts, the spray tip cannot be positioned satisfactorily check the assembly of the entire injector.

i. Installation.

(1) Test the injector (para (d) above).

(2) Ream the beveled seat of the injector tube in the cylinder head. Pack the flutes of the reamer with grease to retain the carbon removed from the tube (fig. 3-23).

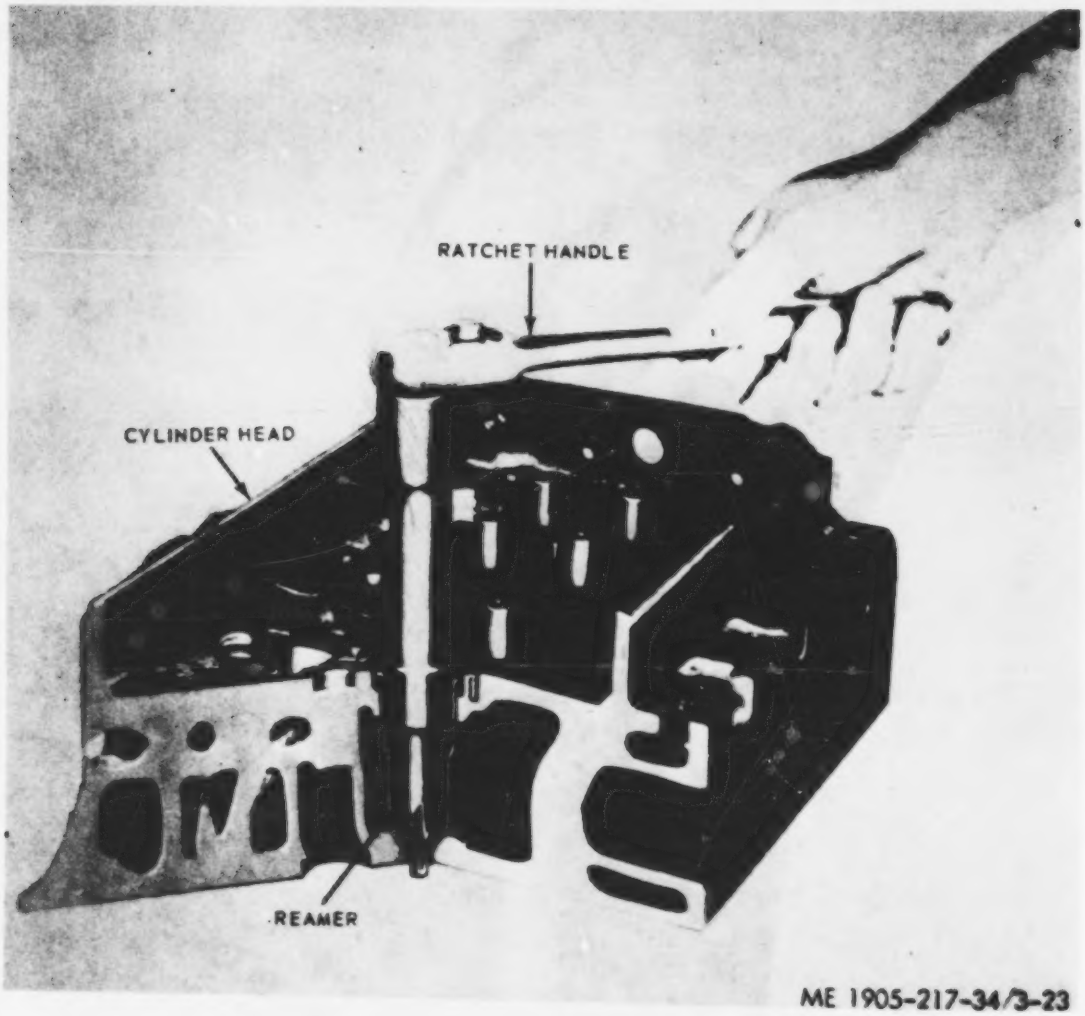


Figure 3-23. Reaming seat of injector tube in cylinder head.

CAUTION

Exercise care to remove only the carbon when reaming the injector tube seat so that the proper clearance can be maintained between the injector body and the cylinder head.

(3) Refer to TM 55-1905-217-12, para 4-28 for installation of the fuel injectors.

3-3. Fuel Pump

a. Removal. Refer to TM 55-1905-217-12, para 4-29, for removal of the fuel pump.

b. Disassembly. With fuel pump removed from the engine and mounted in the holding fixture refer to figure 3-24 and disassemble the pump as follows:

(1) Remove the eight cover bolts, then withdraw the pump cover from the pump body. Use care not to damage the finished faces of the pump body and cover.

(2) Withdraw the drive shaft, drive gear and gear retaining ball as an assembly from the pump body.

(3) Press the drive shaft just far enough to

remove the steel locking ball. Then, invert the shaft and gear assembly in the press, and press the shaft from the gear. Do not misplace the steel ball. Do not press the squared end of the shaft through the gear as slight marks will damage the oil seal contact surface.

(4) Remove the driven shaft and gear as an assembly from the pump body. Do not remove the gear from the shaft. The driven gear and shaft are serviced as an assembly only.

(5) Remove the relief valve plug.

(6) Remove the valve spring, pin and relief valve from the valve cavity in the pump body.

(7) To replace the oil seals, remove with tool as shown in figure 3-24 by clamping the pump body in a bench vise and screwing the threaded end of the tool shaft into the outer oil seal (seal nearest to bolting flange). Then tap the pilot end of the shaft with a hammer to remove the seal. Repeat this operation to remove the inner oil seal.

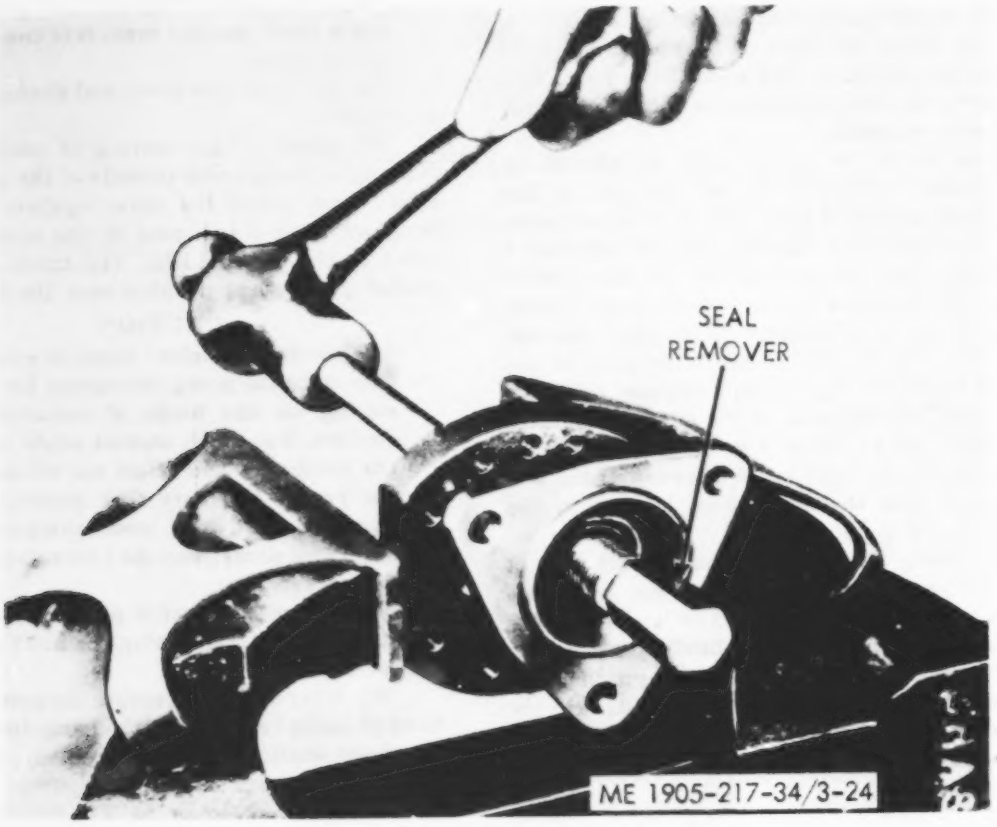


Figure 3-24. Removing oil seals from fuel pump body.

NOTE

Observe the position of the inner oil seal lip before removing the seal to permit installation of a new seal in the same position.

c. *Inspection and Repair.*

(1) Clean all of the parts in clean fuel oil, and dry them with compressed air.

(2) Oil seals, once removed from the pump body, must be discarded and replaced with new seals. The lips of the oil seals must fit snug around the pump shaft and must be free of nicks or cracks.

(3) Check the pump gear teeth for scoring, chipping or wear. Check the ball slot in the drive gear for wear. If necessary, replace with a new gear.

(4) Inspect the drive and driven shafts for scoring or wear. Replace with new shafts if necessary. The driven shaft is serviced as a gear and shaft assembly only.

(5) The mating faces of the pump body and cover must be flat and smooth and fit tightly together. Any scratches or slight damage may result in pressure leaks. Also check for wear at areas contacted by gears and shafts. Replace the cover or body if necessary.

(6) The relief valve must be free from score marks and burrs and fit its seat in the pump body. If the relief valve is scored and cannot be cleaned up with fine emery cloth or crocus cloth, the valve must be replaced.

(7) The valve spring has a free length of 1.97 inches and requires a load of 7.3 ± .2 lbs. to compress it to a length of 1.18 inches when new. If the spring falls below the above specifications, replace the spring.

(8) A fuel pump overhaul kit which contains oil seals, gaskets, shaft and gear assemblies, and relief valve parts is available for service.

d. Reassembly. Reassemble the fuel pump as follows:

(1) Lubricate the lips of the oil seals with a light coat of vegetable shortening, then install the oil seals in the pump body as follows:

(a) Place the inner oil seal on the pilot of the installer handle J 1508 so that the lip of seal will face in the same direction as the original seal which was removed.

(b) With the pump body supported on wood blocks, insert the oil seal and tool in the pump body and drive the seal in until it bottoms.

(c) Place the shorter end of adapter J 1508-9 over the pilot and against the shoulder of the installer handle. Place the outer oil seal on the pilot of the installer handle with the lip of the seal facing the adapter. Then, insert the pilot of the installer handle into the pump body and drive the seal in until the shoulder of the adapter contacts the pump body. Thus the oil seals will be positioned so that the space between them will correspond with the drain holes located in the bottom of the pump body.

(2) Clamp the pump body in the soft jaws of a bench vise with the valve cavity up. Lubricate the outside diameter of the valve and place the valve in the cavity with the hollow end up. Insert the spring inside of the valve and the pin inside of the spring. With a new gasket in place next to the head of the valve plug, place the plug over the spring and thread it into the pump body. Tighten the plug.

(3) Install the fuel pump drive gear over the end of the drive shaft which is not squared (so the slot in the gear will face the plain end of the shaft when installed). This operation is very important, otherwise fine score marks caused by pressing the gear into position from the square end of the shaft may cause rapid wear of the oil seals. Press the gear beyond the gear retaining ball detent. Then, place the ball in the detent and press the gear back until the end of the slot contacts the ball.

(4) Lubricate the pump shaft and insert the square end of the shaft into the opening at the gear side of the pump body and through the oil seals.

(5) Place the driven shaft and gear assembly in the pump body.

CAUTION

The driven gear must be centered on the shaft to give proper end clearance. Also, the chamfered end of the gear teeth of the production gear must face the pump body. If a service replacement gear with slot is used, the slot must face toward the pump cover.

(6) Lubricate the gears and shafts with clean engine oil.

(7) Apply a thin coating of sealant on the face of the pump cover outside of the gear pocket area. Then, place the cover against the pump body with two dowel pins in the cover entering holes in the pump body. The cover can be installed in only one position over the two shafts.

CAUTION

The coating of sealant must be extremely thin since the pump clearances have been set up on the basis of metal-to-metal contact. Too much sealant could increase the clearances and affect the efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

(8) Secure the cover in place with eight bolts and lock washers, tightening the bolts alternately and evenly.

(9) After assembly, rotate the pump shaft by hand to make certain that the parts rotate freely. When the shaft does not rotate freely, attempt to free it by tapping a corner of the pump.

e. Installation. Refer to TM 55-1905-217-12, paragraph 4-29, for installation of the fuel pump.

3-4. Governor and Throttle Controls

a. Removal. Refer to Operator and Organization Maintenance Manual TM 55-1905-217-12, paragraphs 4-30 and 4-32.

b. Disassembly.

(1) Governor cover:

(a) Remove the plug from the throttle shaft (8, fig. 3-25).

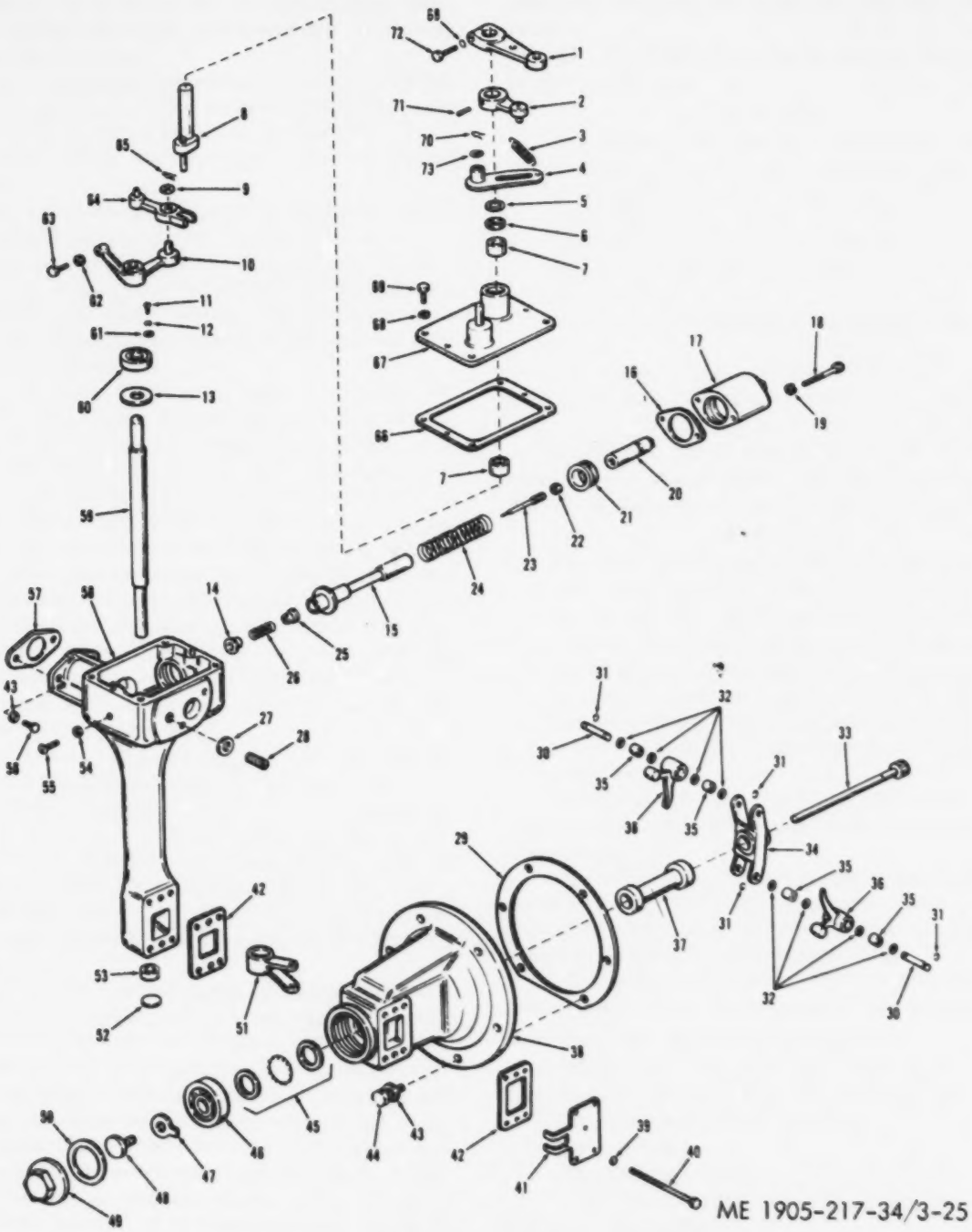


Figure 3-25. Governor and throttle controls, disassembly and reassembly.

Key to Figure 3-25.

1. Speed control lever
2. Throttle shaft lever
3. Cam control spring
4. Cam
5. Seal ring retainer
6. Seal ring
7. Bearing
8. Throttle shaft
9. Washer
10. Operating shaft lever
11. Screw
12. Lock washer
13. Bearing washer
14. Low speed spring cap
15. Plunger
16. Gasket
17. High speed spring retainer cover
18. Bolt
19. Lock washer
20. High speed spring retainer
21. Locknut
22. Locknut
23. Idle speed adjusting screw
24. High speed spring
25. Low speed spring seat
26. Low speed spring
27. Locknut
28. Buffer screw
29. Governor to blower gasket
30. Weight pin
31. Lock ring
32. Washer
33. Shaft assembly
34. Weight carrier
35. Governor weight bearing
36. Weight assembly
37. Governor riser
38. Weight housing
39. Lock washer
40. Bolt
41. Weight housing cover
42. Weight housing cover gasket
43. Copper washer
44. Bolt
45. Riser thrust bearing
46. Shaft end bearing
47. Lock washer
48. Retaining bolt
49. Weight housing plug
50. Gasket
51. Operating shaft fork
52. Expansion plug
53. Operating shaft bushing
54. Washer
55. Screw
56. Bolt
57. Governor to cylinder head gasket
58. Governor control bushing
59. Operating shaft
60. Operating shaft bearing
61. Flat washer
62. Locknut
63. Gap adjusting screw
64. Differential lever
65. Spring retainer
66. Gasket
67. Governor cover
68. Lock washer
69. Screw
70. Spring retainer
71. Pin
72. Bolt
73. Washer

(b) Loosen speed control lever bolt, and lift the speed control lever (1) from the throttle shaft.

(c) Remove the tapered pin from the throttle shaft lever. Lift the lever and the seal ring retainer from the throttle shaft. Withdraw the throttle shaft from the cover.

(d) Remove the cam retainer and plain washer from the cam pin. Lift the cam off the pin.

(e) Remove the seal ring (6) from the governor cover.

(f) Wash the cover assembly (containing needle bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory for further use, removal is necessary.

(g) If needle bearing removal is necessary, place the inner face of the cover over the opening in the bed of the press. Place remover J 21967 on top of the bearing and under the ram of the press; then press both bearings out of the cover,

(2) *Governor control housing:*

(a) Place the control housing in a soft jawed vise.

(b) Remove two bolts (18) and withdraw the high speed spring retainer cover (17).

(c) Loosen the lock nut (21) with tool J 5345-5. Remove the high speed spring retainer (20), idle adjusting screw (23), high speed spring (24), spring plunger, low speed spring (26) spring seat (25), and spring cap (14) as an assembly.

(d) Remove the spring retainer (65) and washer, then lift the differential lever (64) from the pin of operating shaft lever (10).

(e) Remove the expansion plug (52) out of the lower end of the control housing.

(f) Remove the bearing retaining screw (11), flat washer (61), and lock washer.

(g) Support the control housing. Press the operating shaft (59) from the operating fork using a brass rod. Withdraw the operating shaft, operating lever (10) and bearing as an assembly from the control housing.

(h) Support the operating shaft and lever on bed of press. Press the shaft from the operating lever and bearing with a brass rod.

(3) *Governor weight housing:*

(a) Place the weight housing in a soft jawed vise. Remove the plug (49) and gasket (50).

(b) Straighten the tang of the lock washer and remove the bearing retaining bolt (48).

(c) Thread a 5/16 inch-24 x 3 inch bolt into the tapped end of the weight shaft (33). Support the weight housing (38) on the bed of the press and press the shaft from the bearing.

(d) Slide the riser thrust bearing (45) and governor riser (37) from the shaft.

NOTE

This bearing is especially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

(e) Remove the bearing (46) from the weight housing.

(f) Mark the weights (36) and carrier (34) with a center punch for identification, also note position of the thin washers (32) between the weights so that the parts can be replaced in their original position.

(g) If required, the weight carrier (34) may be pressed from the governor weight shaft and a new carrier installed.

c. Cleaning and Inspection.

(1) Clean all parts with cleaning solvent Fed. Spec. PD-680 and dry thoroughly.

(2) Revolve the ball bearings slowly by hand. Replace bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

(3) Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

(4) Inspect the weight carriers, weights and retaining pins for wear.

(5) Inspect the bushings in weights and replace if worn excessively.

(6) Inspect the operating shaft and bushing for excessive wear.

If excessive wear is noted, a new bushing and shaft must be installed.

d. Repair.

(1) Repair all damaged or defective parts as necessary.

(2) Replace a governor and control assembly that is damaged beyond repair.

e. Reassembly.

(1) *Governor cover.*

(a) If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with the number on the bearing up. Insert the bearing installer J21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover.

(b) Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J32068.

NOTE

Do not use impact tools to install needle bearings.

(c) Apply lubricant to the retaining pin and place the cam (4) over the pin with the boss of the cam up. Install the stop lever, if used.

(d) Place the washer over pin and secure with the spring retainer.

(e) Install the plug in the throttle shaft.

(f) Pack the needle bearings (7), with grease. Then, slide the throttle shaft assembly through the bearings.

(g) Insert the seal ring (6) over the shaft and into the counterbore against the upper bearing. Place the retainer (5) over the shaft and against seal ring.

(h) Start the throttle shaft lever (2) over the throttle shaft (8) with the holes in lever and shaft for tapered pin (71) in alinement.

(i) Support the lower end of throttle shaft on the bed of arbor press, then place a sleeve on throttle lever and under ram of press. Aline the slot in cam (4) with pin in throttle lever, then press the lever down on the shaft until hole in the lever is in line with the hole in the shaft.

(j) Insert the tapered pin (71) in the hole of the lever, then support the lever and cover assembly on a steel block and drive the pin into place.

(k) Position the speed control lever (1) on the throttle shaft (8) and tighten the retaining bolt (72).

(l) Attach one end of the spring (3) in small hole of cam (4).

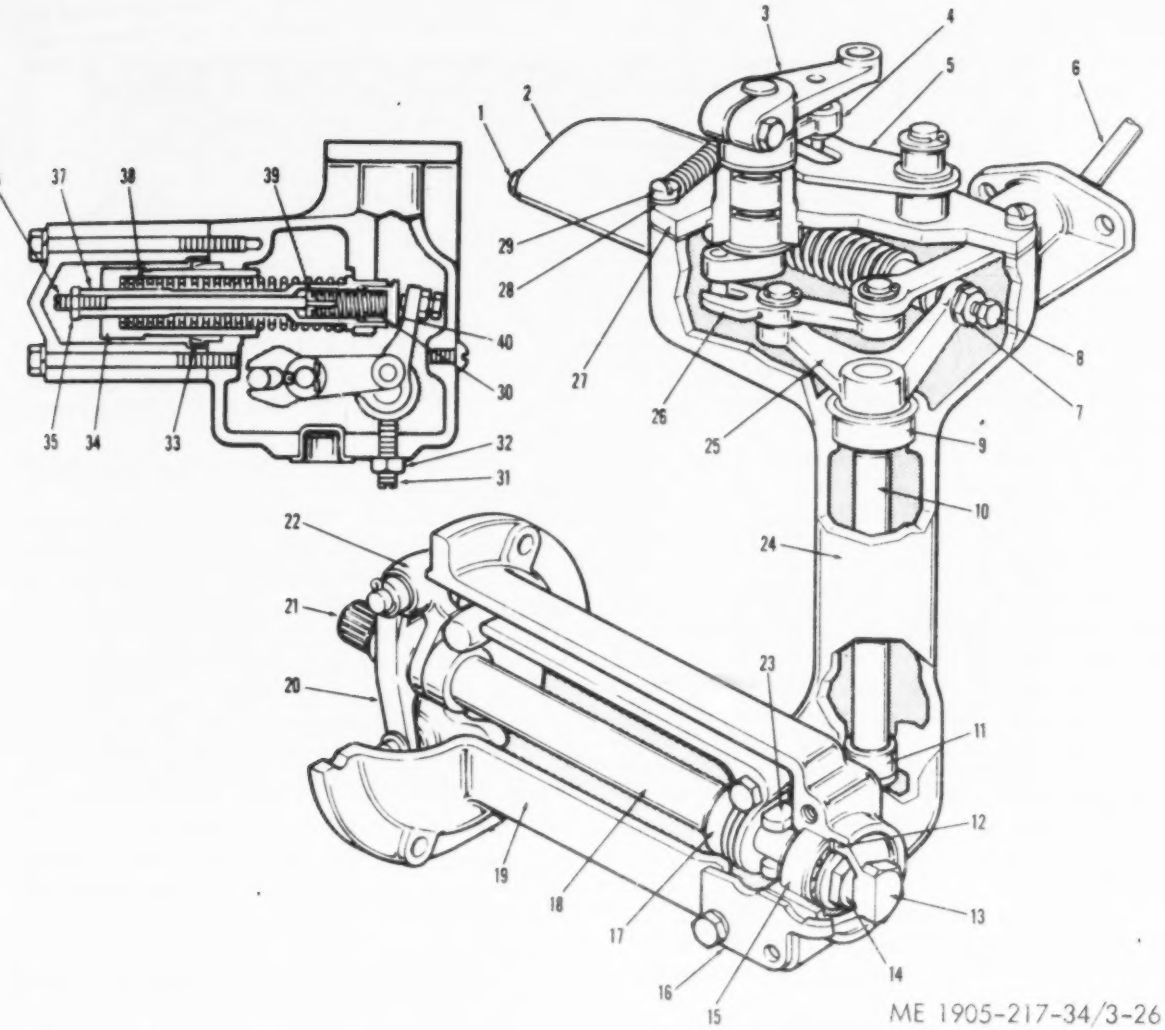
(2) Governor control housing.

(a) Place the washer (13) over short finished end of the operating shaft (59). Start the bearing (60) over end of the shaft. Support the opposite end of the shaft on the bed of a press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

(b) With the pivot pin in the operating lever (10) up, start the lever over the end of shaft with the flat on the shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing (60).

(c) Lubricate the bearing and operating shaft bushing (53) in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.

(d) Position the operating fork (51) over the lower end of the operating shaft, so the finished side of the fork finger will rest against the thrust bearing (45) when assembled as shown in figure 3-26.



1. Bolt
2. High speed spring retainer cover
3. Speed control lever
4. Throttle shaft lever
5. Cam
6. Fuel rod
7. Locknut
8. Gap adjusting screw
9. Operating shaft bearing
10. Operating shaft
11. Operating shaft bushing
12. Gasket
13. Weight housing plug
14. Bolt
15. Shaft end bearing
16. Weight housing cover
17. Riser thrust bearing
18. Governor riser
19. Weight housing
20. Weight carrier
21. Shaft assembly
22. Weight assembly
23. Operating shaft fork
24. Governor control housing
25. Operating shaft lever
26. Differential lever
27. Governor cover
28. Lockwasher
29. Screw
30. Low speed spring
31. Buffer screw
32. Locknut
33. Locknut
34. High speed spring retainer
35. Locknut
36. Idle speed adjusting screw
37. High speed spring plunger
38. High speed spring
39. Low speed spring seat
40. Low speed spring cap

Figure 3-26. Governor—assembled.

(e) Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Aline the flat in the operating fork with the flat on the operating shaft; then, place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder of the shaft.

(f) Apply a good quality sealant around the periphery of the expansion plug (52), and press the plug into the lower end of control housing.

(g) Place a lockwasher and flat washer over the retaining screw (11, fig. 3-25). Thread the screw in the control housing to secure the operating shaft bearing (60).

(h) Place the differential lever (64) over the pivot pin of the operating lever. Install a plain washer and spring retainer (65).

(3) *Governor springs, plungers, and adjusting screw.*

(a) Thread the locknut (27, fig. 3-25) on the buffer screw (28) and thread the buffer screw into the control housing.

(b) Thread the locknut (21) on the high speed spring retainer (20) approximately 1½ inch. Place the high speed spring (24) over the high speed spring plunger (15) with the tightly wound end of the spring against the shouder of the plunger.

(c) Insert the plunger and spring assembly in the high speed spring retainer. Thread the idle screw (23) approximately 1 inch into the tapped end of the plunger. Thread the lock nut (22) over the idle screw.

(d) Insert the low speed spring (26) in the low speed spring cap (14) and the small end of the spring seat (25) in the opposite end of the low speed spring.

(e) Insert the low speed spring seat and low speed spring and cap assembly in the high speed spring plunger (15) with the spring seat (25) against the shoulder of the idle screw (23).

(f) Start the governor high speed spring assembly into the opening of the control housing and thread the high speed spring retainer (20) in the housing approximately 1 inch.

(g) Installation of the high speed spring retainer cover (17) is not required until after the governor has been installed on the engine and the tune-up procedures outlined in the Operator and Organizational Maintenance Manual TM 55-1905-217-12 (para 4-30) have been completed.

(4) *Governor weight housing.*

(a) Install the lock ring (31, fig. 3-25) in the groove of the weight pin (30). Place a flat washer over the pin and against the lock ring.

(b) Start the pin through the opening in the weight carrier. Place a second washer over the pin and against the projecting arm of the weight carrier.

(c) Position the governor weight (36, fig. 3-26) between the projecting arms of the weight carrier. Push the pin through the governor weight.

(d) Place the third flat washer over the pin and against the weight.

(e) Then, push the pin completely through the weight carrier and place the fourth flat washer over the pin and against the projecting arm of the weight carrier. Install a second lock ring in the groove of the weight carrier pin.

(f) Install the second governor weight in a similar manner.

h. Installation. Refer to Operator and Organizational Maintenance Manual TM 55-1905-217-12 (para 4-30).

3-5. Expansion Tank (Fresh Water)

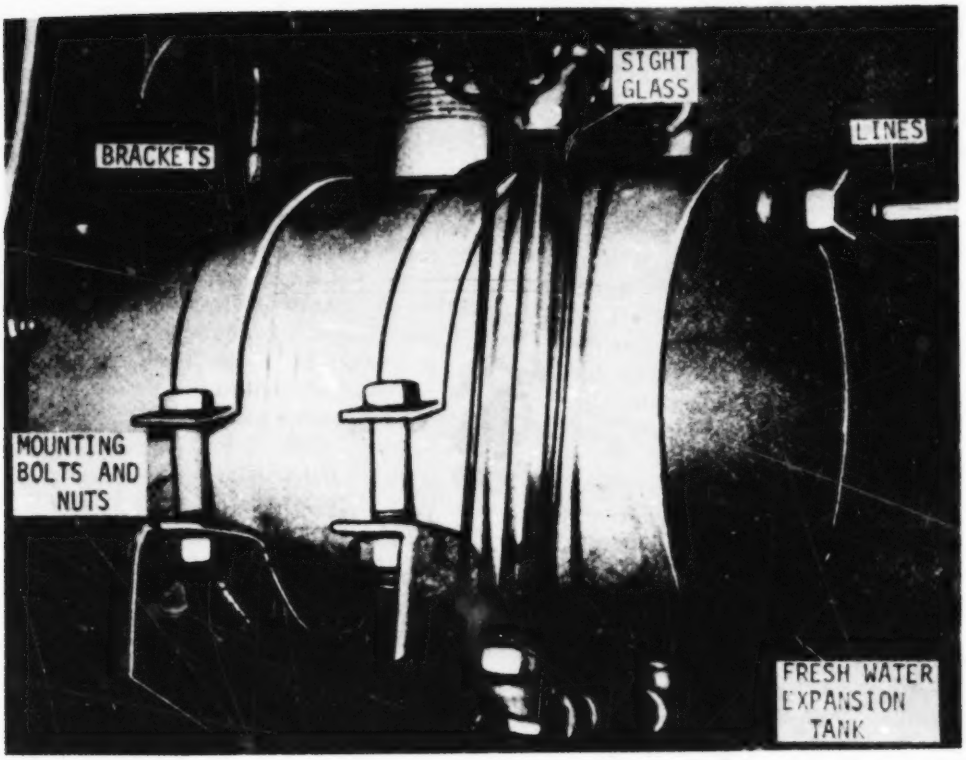
a. Inspection. Inspect the tubes, hoses, connections, and expansion tank for leaks and deterioration.

b. Removal.

(1) Loosen clamps and disconnect lines from expansion tank (Refer to fig 3-27).

(2) Disconnect tubing and remove expansion tank.

c. Installation. Install tank and connect tubing. (fig. 3-27).



TS 1905-217-34/3-27

Figure 3-27. Fresh water expansion tank, removal and installation.

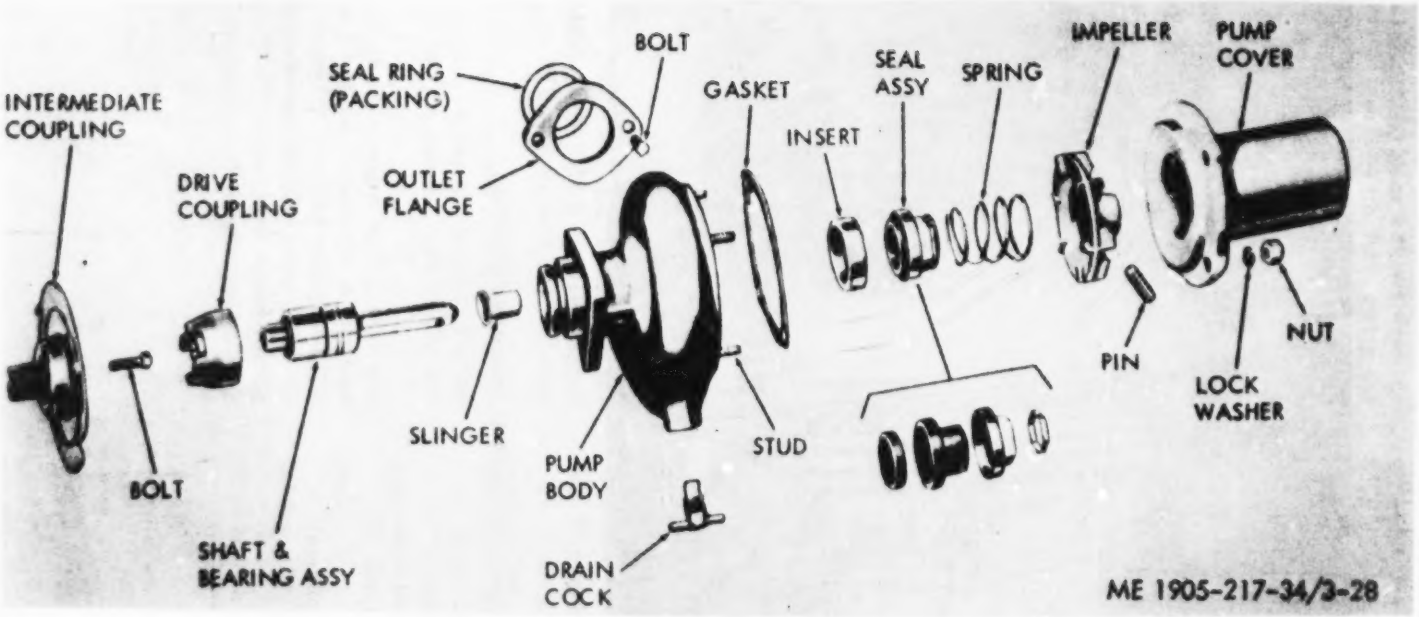


Figure 3-28. Fresh water pump, exploded view.

3-6. Fresh Water Pump

a. Removal. Remove fresh water pump (TM 55-1905-217-12, para 4-45).

b. Disassembly.

(1) Remove the pump cover and gasket (fig. 3-28).

(2) Support the pump on its mounting flange in an arbor press. Place a short steel rod on the shaft and separate the shaft and bearing assembly from the impeller, seal and pump body.

(3) Remove the impeller and seal assembly from the pump body.

(4) If the steel insert is worn excessively, tap or press it out of the pump body.

(5) Remove the water slinger from the shaft.

(6) If the impeller was pinned to the shaft, use a punch and hammer, to remove the sheared tapered pin from the shaft and impeller by tapping against the small end of the pin.

(7) If necessary, remove the pump drive coupling from the shaft using a steel rod clamped in a vise and special tool J 1930.

c. Clean, Inspection and Repair.

(1) Clean all of the parts except the shaft and bearing assembly. The sealed type pump shaft bearing must not be immersed in a cleaning fluid since dirt may be washed in and the fluid cannot be entirely removed.

(2) Revolve the pump shaft bearing slowly by hand. If rough spots are detected, replace the shaft and bearing assembly.

(3) Examine the impeller for wear, and replace it if necessary.

(4) Examine the studs in the pump body. If it is necessary to replace a stud, use a good grade of sealant on the threads and drive the stud in to 10-12 lb-ft torque.

(5) Replace all defective parts as necessary.

(6) Replace a water pump that is damaged beyond repair.

d. Reassembly.

(1) If a new steel insert is to be used in the pump body, make sure the counterbore in the pump body is thoroughly clean before installing a new insert. Dirt in the counterbore can cause misalignment between the insert and the carbon washer and result in a leak at this point. Start the counterbored end of the insert into the pump body. Then, press the insert in until it contacts the shoulder in the pump body. The insert has a .0015 inch-.0035 inch press fit in the pump body.

CAUTION

Do not mar the highly finished seal contact surface of the insert when pressing it into the pump body.

(2) Install the slinger on the pump shaft with the flange of the slinger approximately 3/16 inch from the end of the outer race of the bearing.

(3) Support the impeller end of the pump body on an arbor press, and insert the coupling end of the shaft and bearing assembly into the pump body. Then, press against the outer race of the bearing until the bearing contacts the shoulder in the pump body. Stake the end of the pump body in three places to prevent the bearing from moving endwise.

(4) With the surface of the water pump seal clean and free from dirt and metallic particles, apply a thin coat of liquid soap on the inside diameter of the rubber seal. Do not scratch or mar the surface of the carbon seal washer. Slide the seal assembly on the pump shaft until the carbon seal washer is seated firmly against the pump body insert. Then, install the spring with the small end toward the seal.

(5) Support the bearing end of the shaft (not the drive coupling) on the bed of an arbor press. Then, press the impeller onto the shaft. The end of the shaft must be flush with the face of the impeller hub with the bearing being held against the shoulder in the water pump body.

(6) Support the impeller end of the pump shaft on a suitable arbor and press the coupling onto the shaft. The drive coupling must be flush with the end of the shaft. Make sure the drive coupling is tight on the shaft.

(7) Rotate the shaft by hand to be sure the rear face of the impeller blades do not rub the pump body.

(8) Place a new pump cover gasket against the bolting flange of the pump body. Slide the pump cover over the studs and secure it to the pump body with four lock washers and nuts.

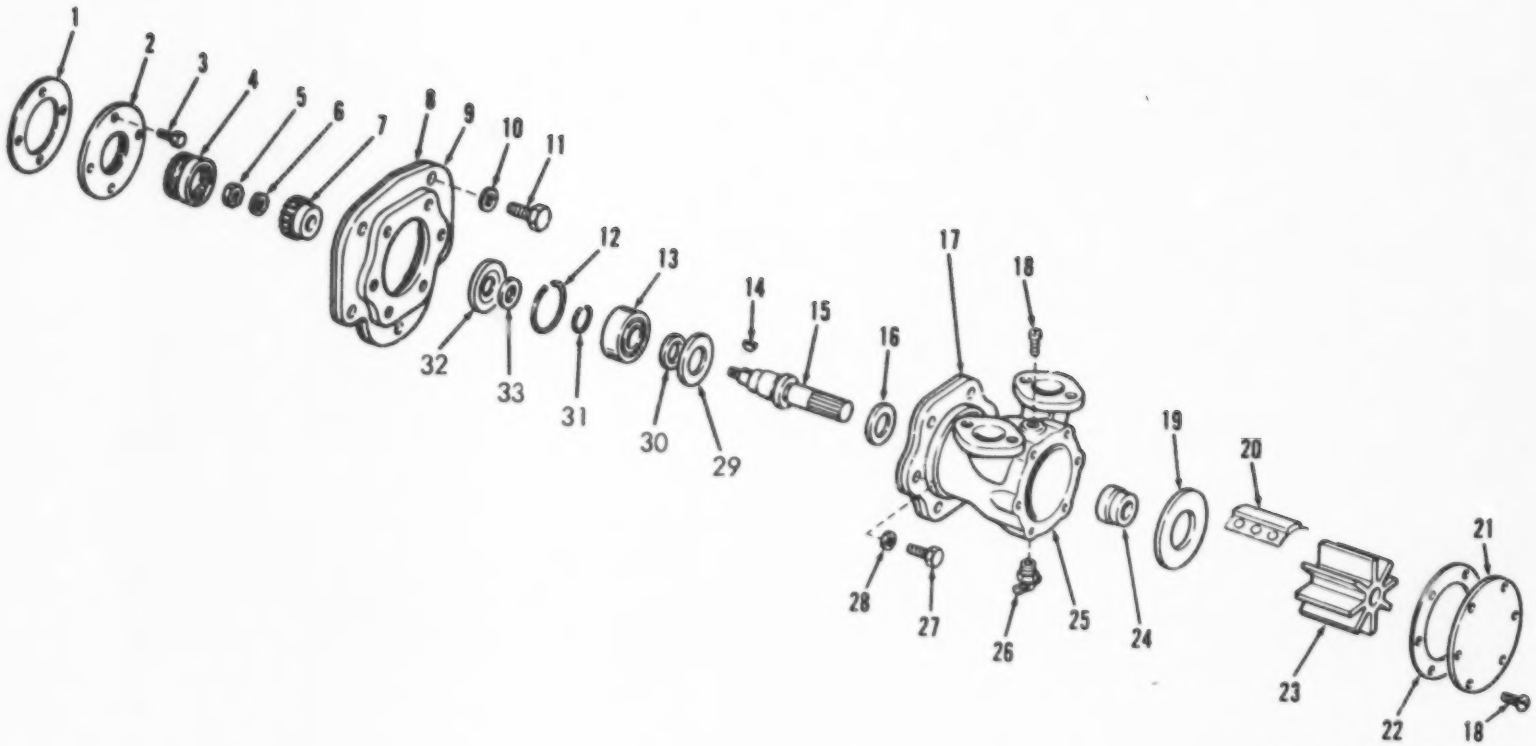
(9) If previously removed, install the drain cock in the pump body.

e. Installation. Install the fresh water pump (TM 55-1905-217-12, para 4-45).

3-7. Raw Water Pump

a. Removal. Remove the raw water pump (TM 55-1905-217-12, para 4-46). Although the raw water pump installed in Hulls 8540 thru 8560 and 8580 thru 8618 is different from the one covered here, the procedures are similar.

b. Disassembly. Refer to figure 3-29 and disassemble the raw water pump.



1. Drive plate spacer
2. Accelerator drive plate
3. Bolt
4. Drive coupling
5. Nut
6. Lockwasher
7. Drive gear
8. Gasket
9. Adapter
10. Lockwasher
11. Screw
12. Retaining ring
13. Ball bearing
14. Woodruff key
15. Shaft
16. Oil slinger
17. Gasket
18. Screw
19. Cam and wear plate assembly
20. Cam, cooler, exhaust
21. Cover
22. Gasket
23. Impeller
24. Seal
25. Body
26. Drain cock
27. Screw
28. Lockwasher
29. Seal
30. Felt washer
31. Retaining ring
32. Seal
33. Felt washer

Figure 3-29. Raw water pump—exploded view.

. Cleaning and Inspection.

(1) Clean all parts with solvent (Fed. Spec. -680), and dry thoroughly.

(2) Inspect all parts for wear and damage.

(3) Replace seals (24), (29), and (30). Replace knut (5).

d. Reassembly. Refer to figure 3-29 and ssemble the raw water pump.

e. Installation. Install the raw water pump M 55-1905-217-12, para 4-46).

3-8. Keel Cooler Heat Exchanger

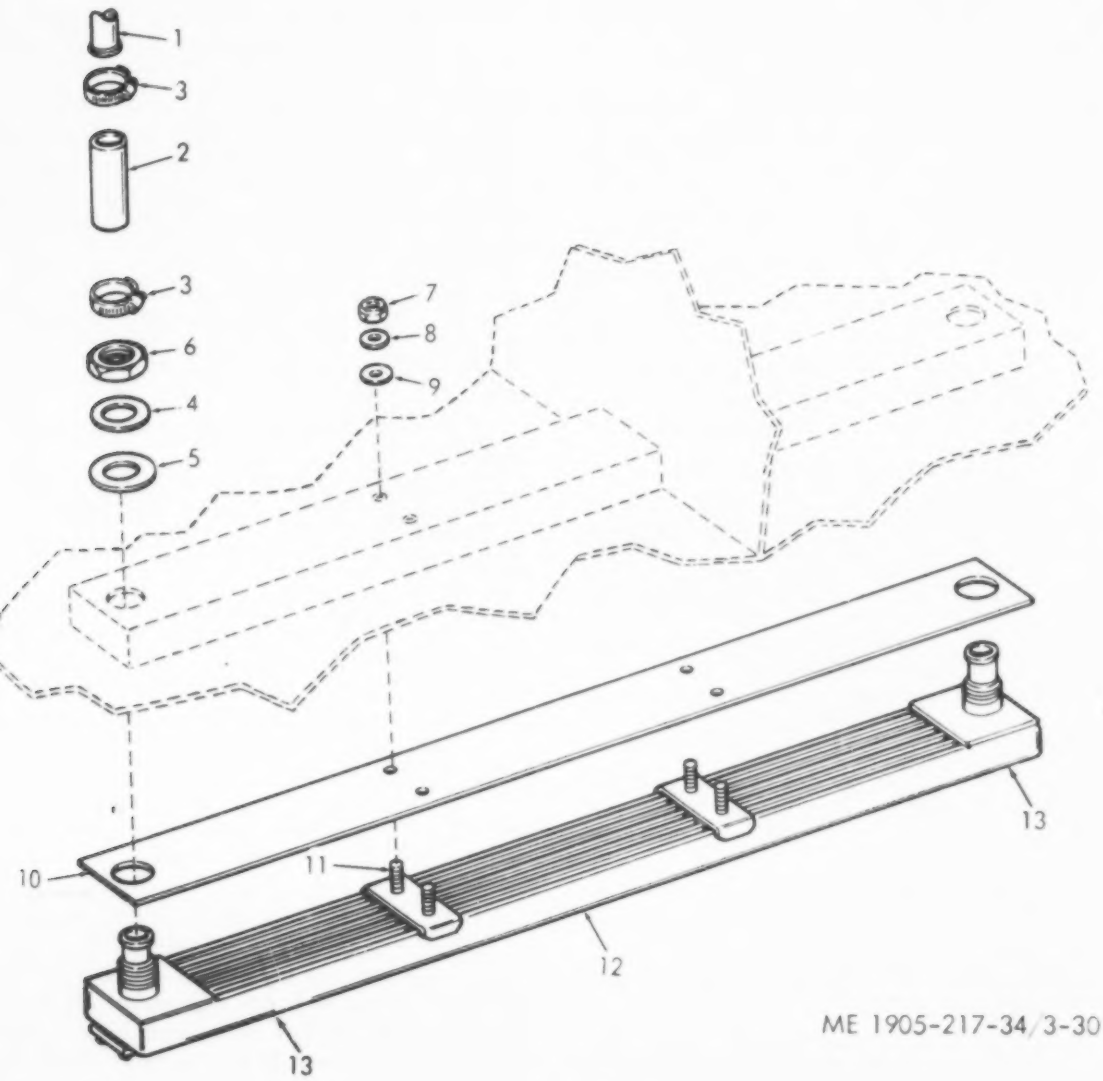
a. Removal.

(1) Raise the landing craft from the water prior to removal of Keel cooler. (TM 55-1905-217-12, para 4-42).

(2) Remove the hose clamps (3, fig. 3-30) and hoses (2).

NOTE

Prior to removal of keel cooler, the cooling system may be drained by removing the drain plug (13, fig. 3-30) from each end of the cooler.



1. Cooling system tubing
2. Rubber hose
3. Hose clamp
4. Washer
5. Inboard gasket
6. Nut
7. Nut
8. Washer
9. Cooler support gasket
10. Cooler mounting gasket
11. Cooler mounting stud
12. Keel cooler
13. Drain plug

Figure 3-30. Keel cooler, removal and installation.

(3) Remove nuts (6), washers (4), and gaskets (5).

(4) Before further removal, station maintenance personnel beneath Keel cooler to lower it when completely detatched from recess.

(5) Remove cooler support nuts (7), washers (8), and gaskets (9) and lower the Keel cooler (12) from recess. Remove gasket (11).

b. Cleaning and Flushing.

(1) Prepare a cleaner solution as follows: In a full gallon container, place ⅔ water and ⅓ Muriatic acid (by volume). After stirring thoroughly, add one pound of Oxalic acid and stir until Oxalic acid dissolves.

(2) Fill cooler with cleaning solution.

(3) Allow solution to stand for a minimum of one minute, but at least until bubbling stops. Empty into sewer or disposal system and flush with fresh water.

(4) Refill cooler with solution and allow to stand until bubbling stops.

(5) Empty cooler of all the cleaning solution and flush cooler thoroughly with hot water.

c. Inspection, Testing, and Repair.

(1) Provide seal of one inlet to hold air under pressure. (Approximately 20 psi.)

(2) Prepare fitting for second inlet that has air line fitting.

(3) Install both inlet fittings.

(4) Pressurize cooler to approximatelv 10 psi and submerge cooler in clear water not allowing "seals" to be surmerged.

(5) Observe any air bubble that would indicate a leak.

(6) If a leak is found, cooler must be replaced.

NOTE

Depending on nature of location of leak, cooler may be repairable.

(7) Inspect tubing for bends or dents.

(8) Inspect inlets for damage to lip or threads.

(9) Straighten or replace damaged tubing.

(10) Replace defective inlets.

(11) Replace all gaskets.

(12) Replace a Keel cooler that is damaged beyond repair.

d. Installation.

(1) Fit mounting gasket (10, fig. 3-30) onto cooler, making certain that cooler surface is free of any debris.

(2) Set cooler into recess in craft hull.

(3) Place support gaskets (9) and then washers (8) onto support bolts. Fit nuts (7) onto bolts and tighten to 7-9 lb-ft of torque.

(4) Place inboard gaskets (5) onto inlet pipes of cooler and then the washers (4).

(5) Fit pipe nuts (6) onto pipes and tighten to 7-9 ft-lb torque.

(6) Place hose clamps (3) onto pipes of cooler and tubing of water system.

(7) Slip rubber hose (2) onto pipes of cooler and water system tubing being certain that hose is fit to allow clamps to have a good grip on hose.

(8) Move clamps onto ends of hose and tighten clamp screws.

(9) Cooling system may now be filled with required solution.

NOTE

The approximate capacity of each cooling system is 25 gallons. When adding antifreeze, refer to TM 55-1905-217-12.

3-9. Blower Assembly

a. Removal. For more simplified removal of the blower assembly; the governor drive, fresh water pump, fuel oil pump, and blower drive shaft cover should be removed altogether with the blower assembly.

(1) Drain the cooling system.

(2) Refer to Operator and Organizational Maintenance Manual TM 55-1905-217-12, paragraph 4-30, and remove the governor control housing assembly.

(3) Disconnect the fuel lines at the fuel pump.

(4) Loosen the fresh water pump connections at the pump cover (inlet) and the cylinder block.

(5) Remove the air silencer and air inlet screen from the blower.

(6) Remove blower drive shaft as follows.

(a) Remove the six bolts that secure the flywheel housing small hole cover.

(b) Remove the snap ring and then pull the blower drive shaft out of the drive assembly.

(c) A broken drive shaft indicates an unusual loading which may have been caused by a bearing failure or other malfunction. Inspect the blower drive, blower rotors and the housing before replacing the drive shaft.

NOTE

Some shafts have a tapped hole in the end which can be used as an aid in removing the shaft.

(7) Loosen the blower drive shaft cover seal clamp at the blower drive gear hub support.

(8) Remove the bolts and plain washers securing the blower to the cylinder block. Slide the blower slightly forward, withdraw the blower drive shaft cover from the seal, then lift the blower away from the cylinder block.

(9) Remove the three bolts and seal washer assemblies securing the fuel pump to the blower rear end plate cover, then remove the fuel pump, gasket and drive coupling fork.

(10) Loosen the seal clamp securing the

lower drive shaft cover to the blower end plate over, then remove cover, seal and clamp from the nd plate cover.

(11) Remove the three bolts and seal washer ssemblies securing the fresh water pump to the lower front end plate cover, then remove the ater pump and gasket. If necessary, tap the ump with a plastic hammer to loosen it.

(12) Remove the six bolts and seal washer ssemblies securing the governor weight housing the blower front end plate cover, then remove he weight housing and gasket.

b. Disassembly. Refer to figure 3-31 and isassemble the blower as follows:

(1) Remove the ten bolts (8) and lockwashers 9) securing the end plate covers (7) and (18) to he blower front (15) and rear end plates (31). Tap he ends of the end plate covers with a plastic ammer to loosen the covers from the gaskets (10) nd dowel pins in the end plates. Then, remove he covers and gaskets from the end plates.

(2) Place a clean folded shop towel between he rotors (29 and 30) and a towel between the otor and the housing (17) to prevent the rotors rom turning. Then, remove the bolt securing the ater pump drive coupling (6) to the blower rotor haft.

(3) Thread adapter J 6471-4 (½ inch-20 hreads) or adapter J 6471-10 (9/16 inch-18) into he water pump drive coupling, then attach slide ammer and shaft J 6471-1 to the adapter and ull the drive coupling from the blower rotor haft.

(4) Refer to figure 3-31 and remove the bolts 19), lockwashers (23) and plain washers (22) ecuring the blower rotor drive hub (20) and drive ub plates (21) to the blower rotor timing gear, hen remove the drive hub, plates and spacers rom the gear. If necessary, remove the three olts(24), lockwashers and plain washers securing he drive plates to the drive hub.

(5) Remove the blower rotor timing gears as ollows:

(a) Remove the bolt (25), lockwasher (26) nd gear retaining washer (27) securing the iming gear (28) to the right-hand helix rotor haft. Then, remove the bolt (25) lockwasher (26) nd fuel pump drive coupling disc (35) securing he timing gear (34) to the left-hand helix rotor haft.

(b) Back out the center screw of both ullers J 6270-1 and secure the pullers to the ears with 5/16 inch-24 x 1½ inch bolts.

NOTE

Both gears must be pulled from the rotor shafts at the same time.

(c) With the shop towels between the blower rotors and housing to prevent them from turning, turn the puller screws uniformly clockwise and pull the gears from the rotor shafts.

(6) Remove the bolts (12) and lockwashers (5) securing the rotor shaft bearing retainers (13) to both the front and rear end plates. Remove the retainers.

(7) Remove the blower rear end plate and bearing assembly from the blower housing and rotors with the two pullers J 6270-1 as follows:

(a) Remove the two fillister head screws (4) securing the rear end plate (31) to the blower housing, and loosen the two fillister head screws securing the front end plate (15) to the housing approximately three turns.

(b) Back out the center screws of the pullers far enough to permit the flange of each puller to lay flat on the face of the end plate.

(c) Secure the pullers to the end plate with six ¼ inch-20 x 1¼ inch bolts.

NOTE

Be sure that the ¼"-20 bolts are threaded all the way into the tapped holes in the end plate to eliminate possible damage to the end plate.

(d) Turn the two puller screws uniformly clockwise and withdraw the end plate and bearings (32) from the blower housing and rotors.

(8) Remove the blower front end plate in the same manner as described above.

(9) Withdraw the blower rotors from the housing.

(10) Remove the bearings (14 and 32) and the lip type oil seals (3) from the blower end plates as follows:

(a) Inspect the oil seals. If the seals are scored, or hard, new seals must be installed. If necessary, the seals may be removed from the end plates at the same time the individual bearings are removed.

(b) Support the outer face of the end plate on wood blocks on the bed of an arbor press.

(c) Place the long end of the oil seal remover and installer J 6270-3 down through the oil seal and into the bearing, with the opposite end of the remover under the ram of the press. Then, press the bearing and oil seal out of the end plate.

(d) Remove the remaining bearings and oil seals from the end plates in the same manner.

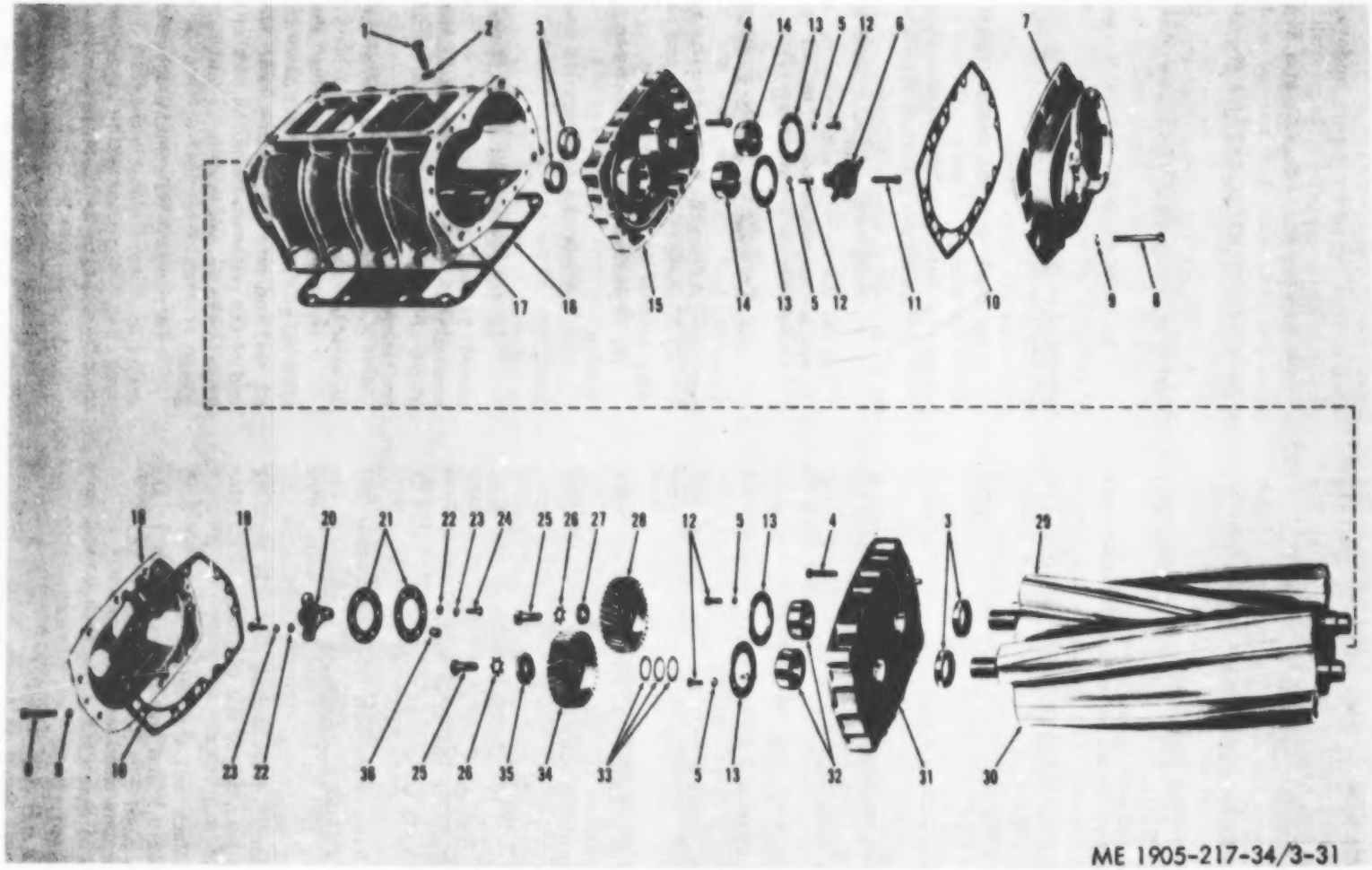


Figure 3-31. Blower, disassembly and reassembly.

Key to figure 3-31.
1. Blower mounting bolt
2. Plain washer
3. Oil seal
4. End plate screw
5. Lock washer
6. Drive coupling
7. Front end plate cover
8. Bolt
9. Lockwasher
10. End plate cover gasket
11. Bolt
12. Bolt
13. Bearing retainer
14. Bearing (roller), front
15. Front end plate
16. Blower housing gasket
17. Blower housing
18. End plate cover
19. Bolt
20. Rotor drive hub
21. Rotor drive hub plate
22. Plain washer
23. Lock washer
24. Bolt
25. Bolt
26. Lockwasher
27. Washer
28. Upper rotor gear (R. H. helix)
29. Upper rotor (R. H. helix)
30. Lower rotor (L. H. helix)
31. Rear end plate
32. Ball bearing
33. Shim (for timing motors)
34. Lower rotor gear (L. H. helix)
35. Fuel pump cooling disc
36. Plate to gear spacer

c. Cleaning and Inspection.

(1) Clean all metal parts with cleaning olvent FED. SPEC. PD-680 and dry thoroughly.

(2) Wash all of the blower parts in clean fuel il and dry them with compressed air.

(3) Examine the bearings for any indications f corrosion or pitting. Lubricate each bearing vith light engine oil; then, while holding the earing inner race from turning, revolve the outer ace slowly by hand and check for rough spots.

NOTE

The double-row ball bearings are pre-loaded and have no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

(4) Check the oil seal rings, carriers and ollars for wear and scoring. If worn excessively, hey must be replaced. Inspection of the type oil eal is covered in paragraph 3-9*c*(10).

NOTE

When a blower with lip type oil seals is being reconditioned, the installation of new seals is recommended. Oversize oil seals and oil seal spacers are available in the blower kit to replace the standard oil seals when the blower rotor shafts are grooved.

(5) Inspect the blower rotor lobes, especially he sealing ribs, for burrs and scoring. Rotors must be smooth for efficient operation of the blower. If the rotors are slightly scored or burred, they may be cleaned up with emery cloth.

(6) Examine the rotor shaft serrations for wear, burrs, or peening. Also, inspect the bearing and oil seal contact surfaces of the shafts for wear and scoring.

(7) Inspect the inside surface of the blower housing for burrs and scoring. The inside surface must be smooth for efficient operation of the blower. If the inside suface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

(8) Check the finished ends of the blower housing, for flatness and burrs. The end plates must set flat against the blower housing.

NOTE

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred it may be cleaned up with emery cloth.

(9) Examine the serrations in the blower timing gears for wear and peening; also check the teeth for wear, chipping or damage. If the gears are worn to the point where the backlash between the gear teeth exceeds .004", or damaged sufficiently to require replacement, both gears must be replaced as a set.

(10) Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent.

(11) Inspect the serrations inside the rotor drive hub for wear and peening.

(12) Inspect the blower drive coupling spring (pack) and the cam for wear.

(13) Replace all worn or excessively damaged blower parts.

d. Repair.

(1) Replace any damaged or defective parts as required.

(2) Replace gaskets.

e. Reassembly. The lobes on the upper blower rotor and the teeth on its gear from a right-hand helix while the lobes and teeth of the lower rotor and gear form a left-hand helix. Therefore, a rotor with right-hand helix lobes must be used with a gear having right-hand helix teeth and vice versa. With this precaution in mind proceed with blower assembly, referring to figure 3-31. Install the lip type oil seals (3) as follows:

(1) Support the blower end plate, finished surface facing up, on wood blocks on the bed of an arbor press.

NOTE

If oversize oil seals are being used in the blower end plates, use installer J 1682-13 to install the oversize oil seal spacers on the rotor shafts.

(2) Start the oil seal straight into the bore in the end plate with the sealing edge facing down (toward the bearing bore).

(3) Place the short end of the oil seal remover and installer J 6270-3 in the oil seal and under the ram of the press. Then, press the oil seal into the end plate until the shoulder on the installer contacts the end plate.

NOTE

A step under the shoulder of the installer will position the oil seal approximately .005 inch below the finished face of the end plate. This is within the .002 inch to .008 inch specified.

(4) Install the remaining oil seals in the end plates in the same manner.

(5) Install the blower front end plate, (15), making sure the mark TOP on the outer ribbed side is at the top of the blower housing, identified by the flange with supports the housing on the top edge of the cylinder block.

NOTE

The front and rear end plates of the blower are nterchangeable.

(6) One end plate should be assembled to the front end of the blower housing first and the other plate should be assembled to the rear of the blower housing after the rotors are in place. Attach an end plate to the front of the blower housing as follows:

(a) Check the dowel pins. The dowel pin must project .380 inch fom the flat inner face and .270 inch from the outer face of the front end plate to assure proper alinement of the end plate to the housing and the cover to the end plate.

(b) Place the blower housing on a bench with the top of the housing up, and the front end of the housing facing the outside of the bench.

(c) Position the end plate in front of the blower housing with the flat finished face of the end plate facing the housing and the end marked TOP facing the flanged side of the housing. Then, start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing. Note that gaskets are not used between the end plates and the housing; therefore, the mating surfaces must be flat and smooth.

(d) Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws securely. Do not use lockwashers on these screws.

(7) Assemble the blower rotors in the blower housing and front end plate as follows. The rotor must be assembled in the blower housing with the omitted serrations in the rotor shafts alined as shown in figure 3-32.

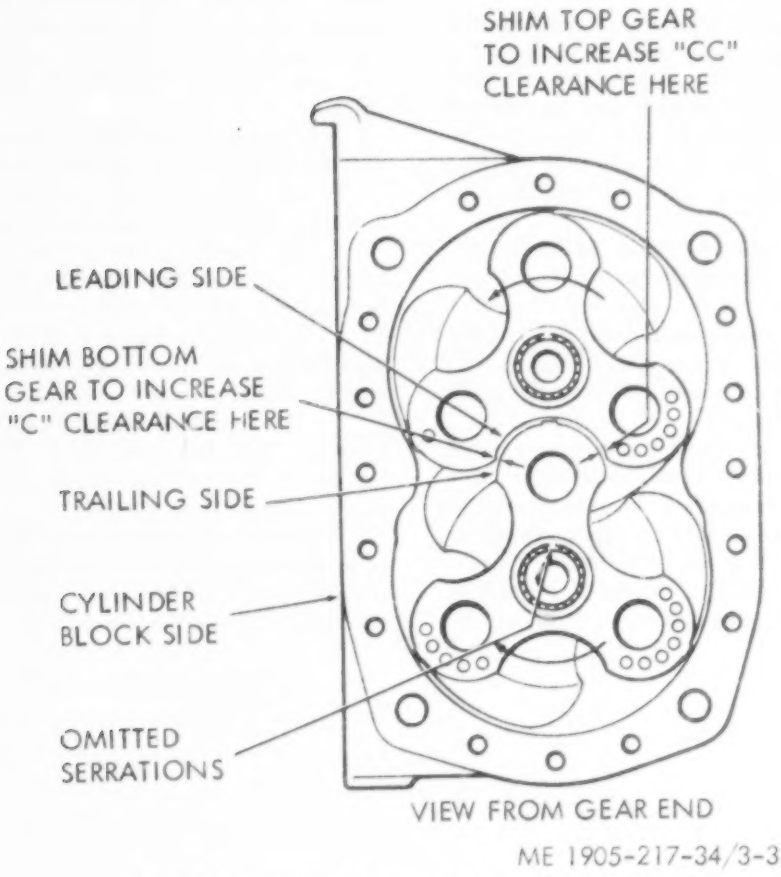


Figure 3-32. Proper shim location for correct rotor lobe clearance.

(a) Place an oil seal pilot J 6270-5 on the short (non-splined) end of each rotor shaft. Then, place the rotors in mesh with the omitted serration in the shafts in alinement as shown in figure 3-32.

NOTE

When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 1682-13 for the oil seal pilots in place of J 6270-5.

(b) Insert the blower rotors with oil seal pilots straight into the blower housing with the righthand helix rotor at the top, flange, side of the housing. Then, push the rotor shafts and oil seal pilots on through the oil seal in the front end plate.

(c) Remove the oil seal pilots from the rotor shafts.

(8) Attach the blower rear end plate to the blower housing as follows:

(a) Reverse the blower housing on the bench (rear end of housing facing the outside of the bench).

(b) Place an oil seal pilot J 6270-5 on the serrated end of each rotor shaft.

NOTE

When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 1682-13 for the oil seal pilots in place of J 6270-5.

(c) Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the rear end plate to assure proper alinement of the end plate to the housing and the cover to the end plate.

(d) Place the rear end plate in position in front of the oil seal pilots with the flat finished face of the end plate facing the blower housing and the mark TOP on the end plate at the top flange side of the housing.

(e) Place the rear end plate over the oil seal pilots and start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing.

(f) Insert the two fillister head screws through the end plate and thread them into the

housing. Tighten the screws securely. Do not use lock washers on these screws.

(g) Remove the oil seal pilots from the rotor shafts.

(9) With the blower housing, rotors and end plates still supported in a vertical position on the two wood blocks, install the roller bearings on the rotor shafts and in the front end plate as follows:

(a) Lubricate one of the roller bearings (14, figure 3-31) with engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

(b) Place installer J 6270-4 on top of the bearing and tap the bearing on the shaft and into the front end plate.

(c) Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lock washers. Tighten the bolts to 7-9 foot-pounds torque.

(10) Start the end of the water pump drive coupling (6) straight into the left-hand helix rotor shaft. Then, place a clean shop towel between the blower rotors to prevent them from turning. Install the drive coupling retaining bolt and draw the coupling and slinger tight against the end of the shaft, then tighten the bolt to 18 foot-pounds torque.

(11) Affix a new gasket (10) to the blower front end plate cover (7).

(12) Position the end plate cover over the end plate dowel pins, with the large hole in the cover toward the top of the end plate, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

(13) Install the ball bearings on the rotor shafts and in the rear end plate as follows:

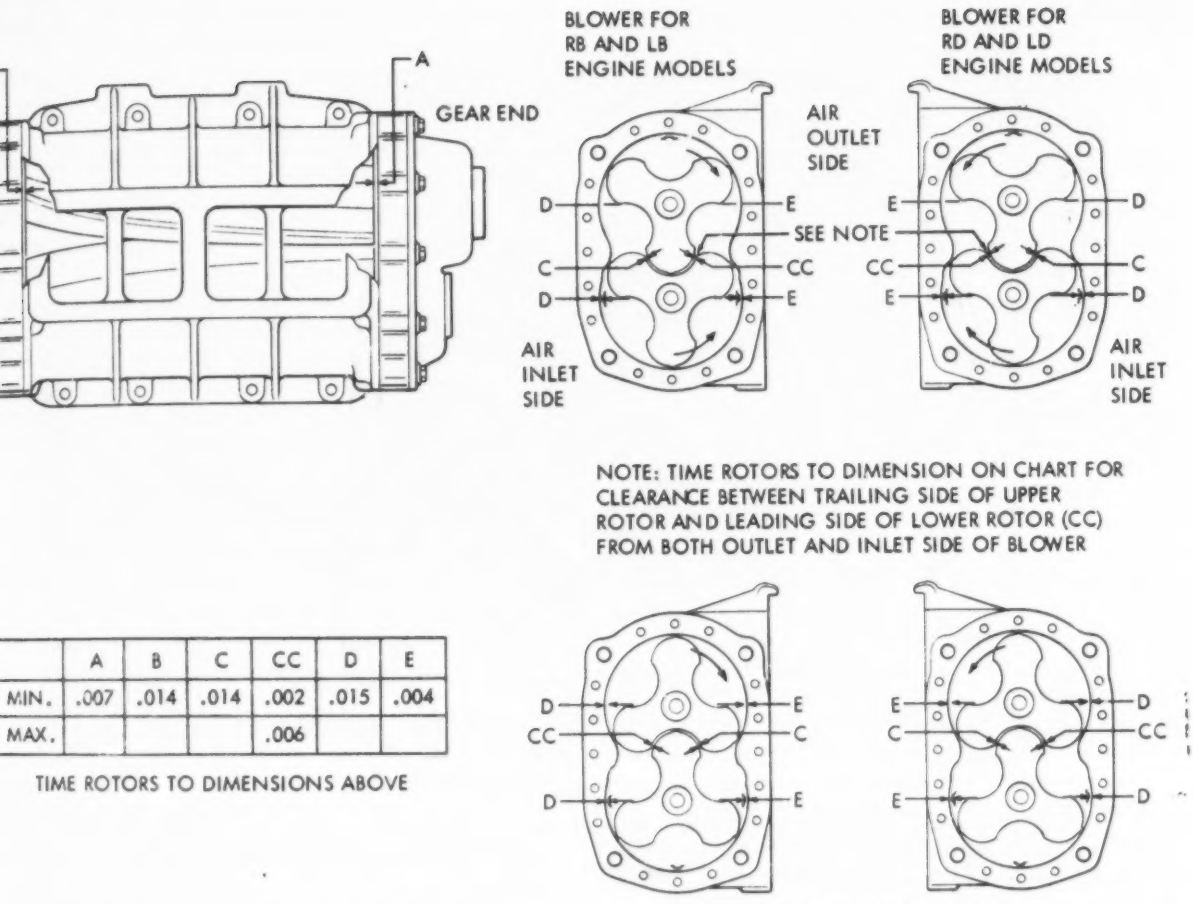
(a) Reverse the position of the blower housing on the two wood blocks, end for end.

(b) Lubricate the ball bearings with engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

(c) Place installer J 6270-7 on top of the bearing and tap the bearing straight on the shaft and into the rear end plate.

(d) Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lockwashers. Tighten the bolts to 7-9 foot-pounds torque.

(14) Make a preliminary check of the rotor-to-end plate and rotor-to-housing clearances at this time with a feeler gage. Refer to figure 3-33 for minimum blower clearances.



	A	B	C	CC	D	E
MIN.	.007	.014	.014	.002	.015	.004
MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

Figure 3-33. Chart of minimum clearances for blower.

(15) Install the blower rotor timing gears blower as follows:

NOTE

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alinement.

(a) Place the blower housing and rotor assembly on the bench with the air inlet side of the housing facing up and the rear end (serrated end of rotor shafts) of the blower facing the outside of the bench.

(b) Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing the top of the blower housing (fig. 3-28).

(c) Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

NOTE

When rebuilding a blower with new rotors or new gears, first install the gears on the rotor shafts without the shims, then check the clearances between the rotors to determine the location and thickness of shims to be used: refer to figure 3-32.

(d) Lubricate the serrations of the rotor shafts with engine oil.

(e) Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the serrations on the shafts.

NOTE

A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in alining the gears on the shafts.

(f) Start both rotor gears straight on the rotor shafts with the right-hand helix gear on the right-hand helix rotor and the left-hand helix gear

on the left-hand helix rotor, and the omitted serrations in the gears in line with the omitted serrations on the rotor shafts.

(g) Thread an installer screw J 6270-8 in the end of each rotor shaft until it bottoms. Place gear installer J 6270-6 over the installer screw and against the right-hand helix gear, and gear installer J 6270-7 over the installer screw and against the left-hand helix gear; then, thread a nut on each installer screw (fig. 3-34).

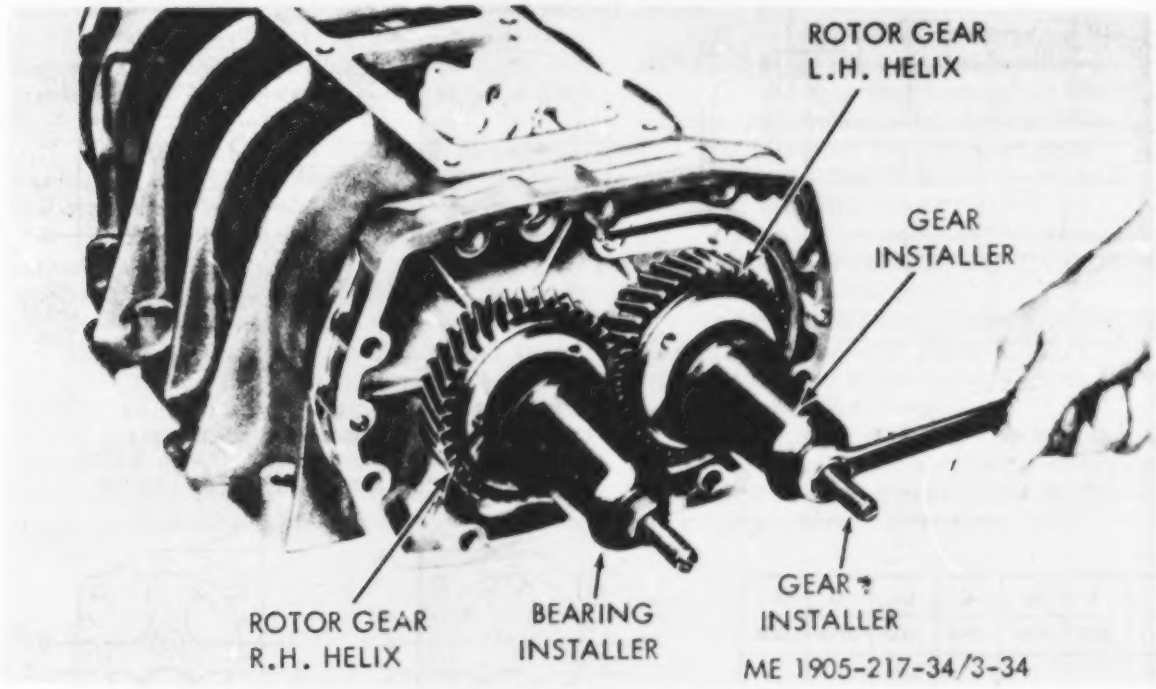


Figure 3-34. Installing rotor gears on shaft for preliminary check of clearance.

(h) Place a clean shop towel between the rotors, and another one between the rotor and the housing to prevent the rotors from turning. Then turn the nuts on the installer screws clockwise and force the gears into position tight against the shims and bearing inner races.

NOTE

Both gears must be pressed on the rotor shafts at the same time.

(i) Remove the rotor timing gear installers from the rotor shafts.

(j) Place a lockwasher (26, fig. 3-31) and the gear retaining washer (27) on one of the gear retaining bolts. Thread the bolt into the right-hand helix rotor shaft, and guide the lugs on the retaining washer in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot of the retaining washer. Tighten the gear retaining bolt to 55-65 lb-ft torque.

(k) Place a lockwasher (26) and the fuel pump drive coupling disc (35) on the remaining gear retaining bolt. Thread the bolt into the left-hand helix rotor shaft and guide the lugs on the disc in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot in the disc. Tighten the gear retaining bolt to 55-65 lb-ft torque.

(l) Bend one of the tangs of each lock washer over against the head of the gear retaining bolt.

(16) After the blower rotors and timing gears are installed, the blower rotors must be timed.

(17) The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

(18) If the right-hand helix gear (28) is moved out, the right-hand helix rotor (29) will turn counterclockwise when viewed from the gear end. If the left-hand helix gear is moved out, the left-hand helix rotor (30) will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

(19) Moving the gears OUT or IN on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

(20) The clearance between the rotor lobes should be checked with ½ feeler gages. When measuring clearances of more than .005 inch, laminated feeler gages that are made up of .002

inch .003 inch or .005 inch feeler stock are more practical and suitable than a single feeler gage. Clearances should be measured from both the inlet and outlet sides of the blower. Use feeler gage set J 1698-02.

(21) A specially designed feeler gage set J 1698-02 for the blower clearance operation is available. Time the rotors as follows:

(a) Time the rotor to have .002 inch to .006 inch clearance between the TRAILING edge of the UPPER rotor and LEADING edge of the LOWER rotor ("cc" clearance) measured from both the inlet and outlet sides as shown in figure 3-29. If possible, keep this clearance to the minimum (.002 inch). The check the clearance between the LEADING edge of the UPPER and the TRAILING edge of the Lower rotors ("cc" clearance) for the minimum clearance shown. Rotor-to-rotor measurements should be taken 1 inch from the governor end, at the center, and 1 inch from the drive end.

(b) After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear as shown in figure 3-32 to produce the desired result. When more or less shims are required, both gears must be removed from the rotors. Placing a .003 inch shim in back of a rotor gear will revolve the rotor .001 inch.

(c) Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

(d) Determine the minimum clearances at points "A" and "B" shown in figure 3-33. Insert the feeler gages between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making twelve measurements in all.

(e) Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side—twelve measurements in all. See figure 3-33 for the minimum clearances.

(22) After the blower rotors are timed, complete the assembly of the blower as outlined below.

(23) Refer to figure 3-31 and attach the blower rotor drive hub (20) and drive hub plates (21) to the blower gear as follows:

(a) Attach the rotor drive hub plates (21) to the drive hub (20) with three bolts (24), lock-washers and plain washers. Tighten the bolts to 25-30 lb-ft torque.

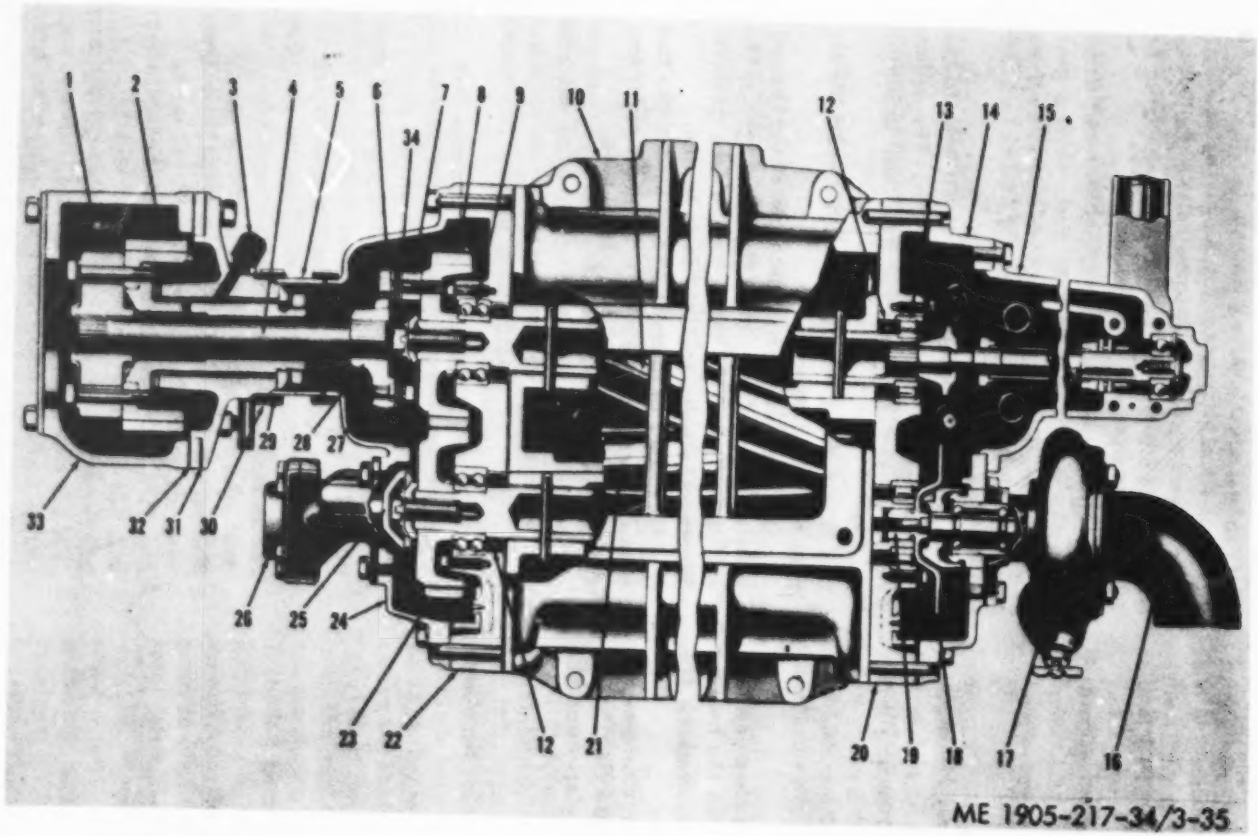
(b) Attach the rotor drive hub and drive plates to the right-hand helix rotor timing gear with three bolts (19), lock washers, plain washers and three spacers (36). Tighten the bolts to 25-30 lb-ft torque.

(c) Check the runout of the splines in the rotor drive hub with an indicator. The spline runout must not exceed .020 inch total indicator reading.

(24) Affix a new gasket (10) to the blower rear end plate cover (18).

(25) Position the end plate cover over the end plate dowel pins, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

(26) Refer to figure 3-35 and attach the fuel pump, water pump, blower drive shaft cover and governor weight housing to the blower.



Key to figure 3-35.

1. Coupling assembly
2. Blower drive gear
3. Elbow (90°), oil line to blower drive
4. Blower drive shaft
5. Blower drive shaft cover
6. Bolt
7. Plate to gear spacer
8. Upper rotor gear (R. H. helix)
9. Ball bearing
10. Blower housing
11. Upper rotor (R. H. helix)
12. End plate oil seal
13. Roller bearing
14. End plate cover
15. Governor
16. Water pump inlet cover.
17. Fresh water pump
18. Coupling assembly
19. Bolt
20. Front end plate
21. Lower rotor (L. H. helix)
22. Lower rotor (L. H. helix)
23. Lower rotor gear (L. H. helix)
24. End plate cover
25. Fuel pump drive fork
26. Fuel pump
27. Bolt
28. Rotor drive gear hub
29. Drive shaft cover seal
30. Drive cover seal clamp
31. Blower drive gear hub support
32. Cylinder block end plate
33. Flywheel housing
34. Blower rotor drive hub plate

Figure 3-35. Blower and drive assembly with accessories attached to blower.

(27) Attach the blower drive shaft cover (5) to the blower rear end plate cover (24) with cover seal (29) and seal clamp.

f. Installation. Before attaching the blower to the engine, check the inside of blower for any foreign material and revolve rotors by hand to be sure they turn freely.

(1) Affix a new blower to block gasket to the cylinder block with a non-hardening gasket sealant on the block side only.

(2) Place a new drive shaft cover seal (29, fig. 3-35) and seal clamp over the end of the drive shaft cover (5).

(3) Place the water pump outlet packing flange, flat face toward pump body, and slide a new packing ring over the pump outlet. Then, place a new water pump cover seal and clamp on top of the oil cooler housing outlet opening.

(4) Place the blower assembly into position against the cylinder block, being careful not to dislodge the blower gasket.

(5) Install the eight blower to cylinder block bolts and plain washers, and tighten bolts to 55-60 lb-ft torque.

(6) Slide the blower drive shaft cover seal (29) into position against the blower drive gear hub support and tighten the seal clamp.

(7) Install the blower drive shaft (4) by pushing the plain end, without squared hole, of the shaft through the blower drive coupling from the rear of the engine, then into the blower drive gear hub. If necessary, rotate the blower rotors slightly to aline the splines of the drive shaft with those in the gear hub. Then, install the lock ring in the blower drive cam.

(8) Install the flywheel housing small hole cover.

3-10. Transmission Control Valve

a. Removal.

(1) The transmission control valve is mounted on the reduction gear housing at the rear of the engine.

(2) Disconnect operating linkage from transmission control valve.

(3) Disconnect oil supply hoses from control valve.

(4) Remove the bolts and lockwashers securing each oil tube assembly to the reverse gear housings.

(5) Remove the four bolts and copper washers securing the oil tube assembly to the top of the control valve. Remove oil tube assemblies and gaskets.

(6) Remove the four bolts, lockwashers, and plain washers securing the control valve assembly to the reduction gear housing cover. Then lift the control valve assembly from the reduction gear housing cover.

b. Disassembly.

(1) Remove the locating screws (20, fig. 3-36) (one for each shutoff valve) and copper washer from the sides of the control valve housing.

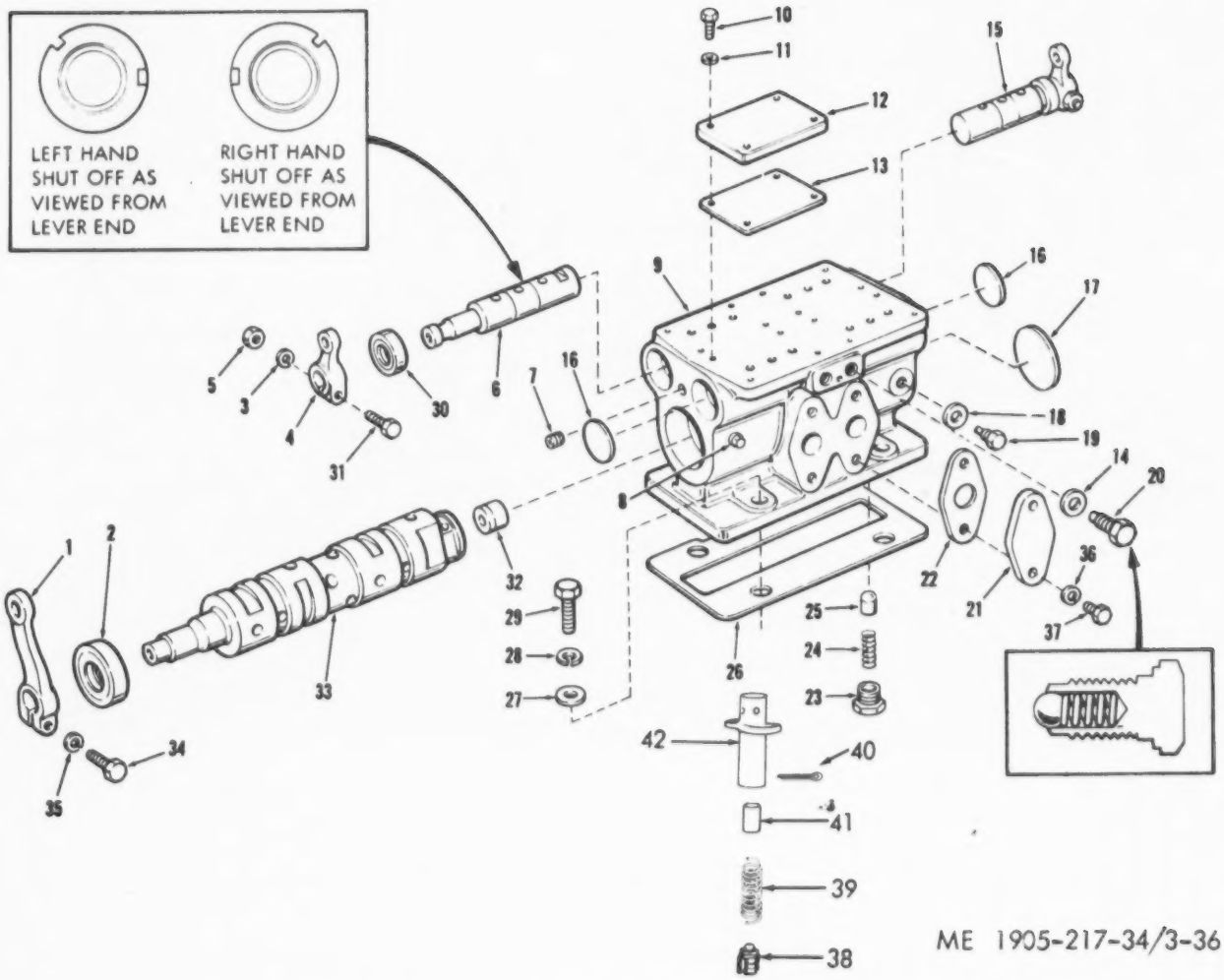


Figure 3-36. Transmission control valve, exploded view.

to figure 3-36.
Selector valve lever
Oil seal
Lockwasher
Shut off valve lever
Nut
Shutoff valve
Plug
Plug
Control valve housing
Bolt
Lockwasher
Cover
Gasket
Gasket
Shutoff valve assembly
Plug
Plug
Washer
Locating screw
Locating screw
Cover
Gasket
Plug
Poppet spring
Poppet
Gasket
Washer
Lockwasher
Bolt
Oil seal
Bolt
Plug
Selector control valve
Bolt
Lockwasher
Lockwasher
Bolt
Seat
Spring
Cotter pin
Pressure regulating valve
Body

(2) With the control valve housing (a) ported in a vertical position, place two small d blocks on the end of the housing and, using bars spaced 180° apart under the shut off e lever as shown in figure 3-37, pry the off valve oil seal (2) out of the housing. The, ove the shutoff valve and oil seal as an mbly from the housing.

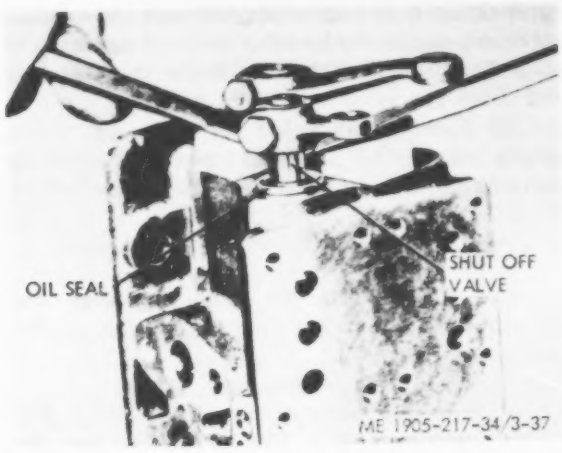


Figure 3-37. Removing shutoff valve oil seal from control housing.

(3) Remove the shutoff valve lever attaching bolt (31), figure 3-36, and tap the lever (4) from the end of the shut off valve. Then, remove the oil seal (30) from the shut off valve.

(4) Remove the remaining shutoff valve and oil seal from the control valve housing and disassemble.

(5) Remove the selector valve poppet plug (23) from the bottom side of the control valve housing; then, remove the poppet spring (24) and the selector valve poppet (25) from the housing.

(6) Support the control valve housing in a vertical position with the lever end up. Place two small wood blocks on the end of the housing and, using pry bars spaced 180° apart under the selector valve lever, pry the selector valve oil seal (2) out of the housing. Then, remove the selector valve and oil seal as an assembly from the housing.

(7) Loosen the selector valve lever attaching bolt and tap the lever (1) from the end of the selector valve. Then, remove the oil seal (2) from the selector valve.

(8) If the control valve housing plug (17) is to be removed, insert a ½ inch diameter steel rod

approximately 10 inches long through the selector valve opening in the housing and rest against the plug. Tap the end of the steel rod with a hammer and drive the plug out of the housing.

(9) Remove the valve seat (38, fig. 3-36), spring (39), cotter pin (40), pressure regualting valve (41) and body (42) from the control valve.

NOTE

The pressure regulating valve components apply to Rohr Hulls only.

(10) Remove the oil passage covers and gaskets from the sides and top of the control valve housing.

c. Cleaning, Inspection, and Repair.

(1) Wash all parts of the control valve with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly. Be sure to clean all oil passages with compressed air.

(2) Examine the oil seals, and if the lip of the oil seal is rough or charred, replace the oil seals.

(3) Examine the outer surfaces of the selector valve and shutoff valves for roughness and score marks; also, check the selector valve poppet seat in the selector valve and the shutoff locating screw ball seat in the shutoff valves for wear. If the selector valve and poppet seat, or the shutoff valves and locating screw ball seats are worn or scored, replace the selector valve, shutoff valves and control valve housing.

NOTE

The selector valve, shutoff valves and control valve housing are not serviced separately.

(4) If the selector valve poppet or the shutoff locating screw balls are worn or scored, replace.

(5) Remove all traces of old gaskets from the control valve housing, oil hole covers on twin units and flanges of oil tube assemblies.

d. Reassembly.

(1) Install the shutoff valve (6) in the control valve housing as follows:

(a) Place the control valve housing (9) on the work bench with the top of the housing facing up.

NOTE

The right-hand and left-hand shutoff valves must be assembled in the correct bores in the control valve housing; therefore, viewing the control valve housing from the end, the right-hand shutoff valve must be assembled into the upper right-hand opening in the housing and the left-hand shutoff valve into the upper left-hand opening in the housing. Right-hand and left-hand shutoff valves may be identified from the two end views of the valves shown in the inset of figure 3-36.

(b) Lubricate the shutoff valve (6) with engine oil. Then, start the shutoff valve straight into the bore of the housing with the locating screw slot in alignment with the locating screw hole in the side of the housing. Continue to slide the shutoff valve in the housing until the slot in the valve is in line with the locating screw hole.

(c) Place a copper washer over the end of the shut off locating screw (20). Then, install the screw in the control valve housing with the steel ball in the end screw registering with the slot in the shutoff valve. Tighten the screw to 35-39 ft-lb torque.

(d) Stand the control valve housing in a vertical position with the outer end of the shutoff valve facing up.

(e) Apply a thin coat of sealing compound to the outside diameter of the oil seal (3).

(f) Place the shutoff valve oil seal (30) over the end of the shutoff valve with the lip of the oil seal facing the housing. Then, start the oil seal straight into the control valve housing.

CAUTION

Care should be used not to damage the lip when installing the oil seal over the end of the shutoff valve.

(g) Place a small wood block 1 inch thick with a ½ inch hole drilled through its center over the end of the shutoff valve and against the oil seal, (fig. 3-38). Then, tap the oil seal straight into the housing until it is flush with the outside face of the housing.

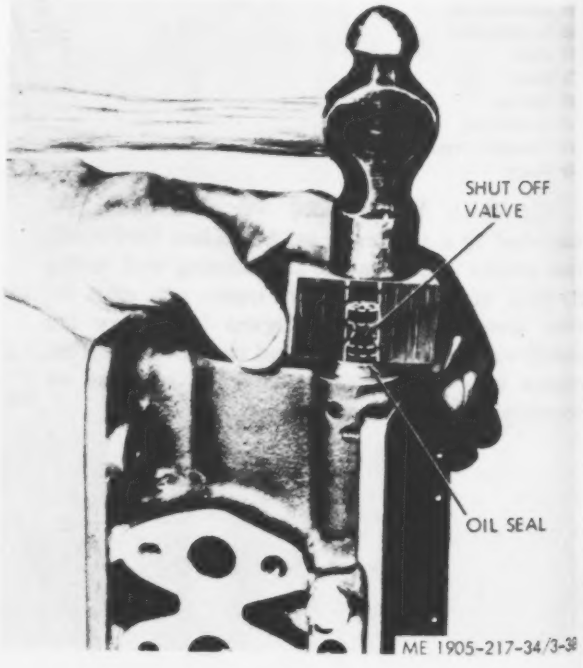


Figure 3-38. Installing shutoff valve oil seal in control valve housing.

(2) Install the selector valve in the control valve housing as follows:

(a) Lubricate the selector valve with engine

. Then, start the locating screw slot end of the lector valve straight into the control valve using with the locating screw (19, fig. 3-36) le in the right-hand side of the housing. ntinue to slide the selector valve in the housing til the slot in the valve is in line with the ating screw hole.

(b) Place the copper washer over the end of e selector valve locating screw (19). Then, stall the screw in the control valve housing with e end of the screw registering with the slot in e selector valve. Tighten the screw to 13-17 ft-lb rque.

(c) Support the control valve housing in a rtical position with the lever end of the selector lve facing up.

(d) Apply a thin coat of sealing compound the outside diameter of the oil seal (2).

(e) Place the selector valve oil seal (2) over e end of the selector valve with the lip of the oil al facing the housing. Then, start the oil seal raight into the control valve housing.

CAUTION

Care should be used not to damage the lip when installing the oil seal over the end and shoulder of the selector valve.

(f) Place a small wood block, 1½ inches ick, with a 7/8 inch hole drilled through its nter, over the end of the selector valve and gainst the oil seal. Then, tap the oil seal straight to the housing until it is flush with the outside ce of the housing.

(3) If removed, apply a thin coat of sealing mpound to the outside diameter of the control lve housing plug (17). Then, place the plug in e opening in the end of the housing with the nvex side of the plug facing out. Place a ½ inch ameter drift against the center of the plug; en, tap the drift with a hammer and securing e plug in the housing.

(4) Lubricate the selector valve poppet (25) ith engine oil. Place the pointed end of the ppet in the hole in the bottom side of the using. Then, insert the poppet spring inside the ppet and secure in place with plug. Tighten the ppet plug to 107-117 ft-lb torque.

(5) Aline the oil passages in each shutoff lve with the oil passages in the top of the ntrol valve housing. Then, place a shutoff valve ver on each shutoff valve with the arm of the ver pointing straight up. Secure each lever with bolt, lock washer and nut. Tighten the bolt nut 8-10 ft-lb torque.

(6) Operate each shutoff valve to check for ease of operation. Also, check the alinement of the oil passages when the levers are positioned straight up.

(7) Rotate the selector valve to the neutral position-midway between the forward and reverse positions-then, place the selector valve lever over the end of the selector valve with the arm of the lever pointing straight up. Tighten the lever attaching bolt to 7-9 ft-lb torque.

(8) Install the covers and gaskets over the oil passage openings in the sides and top of the control valve housing that are not being used. Tighten the ¼ inch-20 cover bolts to 7-9 ft-lb torque, and 5/16 inch-18 cover bolts to 13-17 ft-lb torque.

e. Installation.

(1) Affix a new gasket to the bottom side of the control valve housing. Then, place the control valve assembly over the opening in the top of the reduction gear housing cover with the bolt holes in alinement, and the lever attaching end of the selector valve facing the control side of the unit.

(2) Install the four bolts, lockwasher and plain washers securing the control valve housing to the reduction gear housing cover. Tighten the bolts to 35-39 ft-lb torque.

(3) Connect the two oil cooler to control valve oil tubes to the back of the control valve housing.

(4) Affix a new gasket to the control valve end and a new gasket to the reverse gear housing end of each oil tube assembly.

(5) Attach the end of the tube to the control valve housing with four ¼ inch-20 x 7/8 inch bolts and copper washers. Attach the opposite end of the oil tube to the reverse gear housing with four 5/6 inch-18 x 1 inch bolts and lock-washers. Tighten the ¼ inch-20 bolts to 7-9 ft-lb torque and the 5/16 inch -18 to 13-17 ft-lb torque.

(6) Attach operating linkage to the control valve lever.

3-11. Transmission Oil Pump

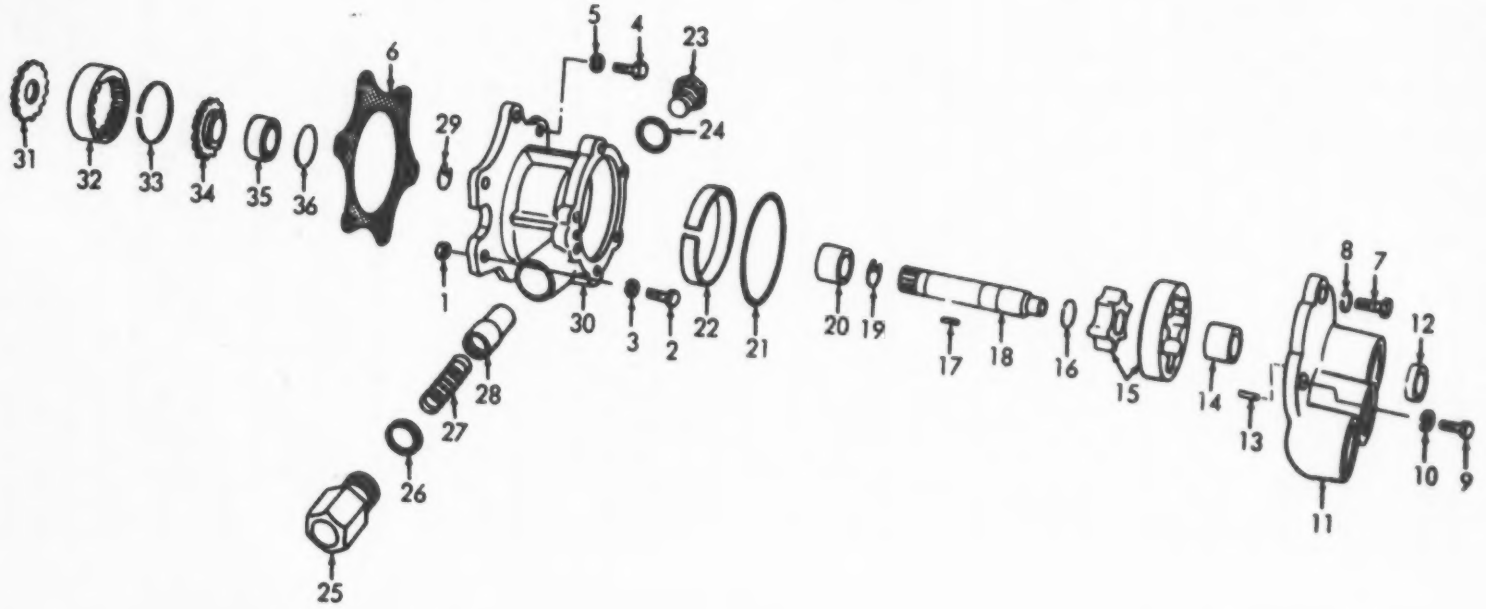
a. Removal. Remove the transmission oil pump (TM 55-1905-217-12, para 4-70).

b. Disassembly.

(1) Clamp the flange of the pump body in a bench vise.

(2) Remove the tachometer drive and adapter assembly from the pump.

(3) Refer to figure 3-39 and disassemble the oil pump.



TS 1905-217-34/3-39

1. Nut, plain, hex
2. Screw
3. Lockwasher
4. Capscrew
5. Lockwasher
6. Gasket
7. Capscrew
8. Lockwasher
9. Capscrew
10. Lockwasher
11. Cover
12. Seal, pump cover
13. Dowel pin
14. Bearing, sleeve
15. Rotor set
16. Ring, retaining
17. Pin, drive
18. Shaft, pump
19. Ring, retaining
20. Bearing, sleeve
21. Washer, non-metallic
22. Bushing, rotor
23. Screw, valve
24. Gasket
25. Adapter screw
26. Gasket
27. Spring, flow control valve
28. Valve assembly, relief
29. Ring, retaining
30. Oil pump body
31. Spur gear
32. Insert
33. Ring, retaining pump coupling
34. Spur gear
35. Seal
36. Washer, non-metallic

Figure 3-39. Transmission oil pump, disassembly and reassembly

c. Cleaning, Inspection and Repair.

(1) Wash all of the oil pump parts in solvent (FED SPEC. PD-680), blow dry with compressed air, then inspect.

(2) If the lip of the oil pump cover oil seal is rough or charred, replace the oil seal.

NOTE

Any time the oil pump drive shaft has been removed from the oil pump body, the oil seals and seal gasket in the oil pump body must be replaced with new oil seals and seal gasket.

(3) If the oil pump body and cover bushings are worn excessively or scored, they must be replaced. Clearance between the shaft and shaft bushings should be between .0016 inch and .0035 inch.

(4) If the rotor bushing is scored or worn excessively, it must be replaced.

(5) Examine the oil pump shaft for wear and scoring where the shaft contacts the bushings and oil seals. Also examine the serrations on the end of the drive shaft for peening and wear. If the serrations are peened or worn excessively, or the shaft is scored and cannot be suitably cleaned up with fine emery paper or crocus cloth, it must be replaced.

(6) The rotor cavity in the pump body must be perfectly smooth for efficient operation. Examine the cavity for score marks.

(7) The mating faces of the pump body and cover must be perfectly flat so when they are bolted together they form a tight joint. If the body and cover do not join tightly, leakage is not only apt to occur, but the proper clearance between the rotors and the body and cover will not be maintained.

(8) Examine the inner and outer rotors. If the rotors are worn or scored excessively, they must be replaced. The end clearance of the rotors must be replaced. The end clearance of the rotors is the clearance between the cover face of the body and the rotor set when placed in the rotor pocket and should be between .0015 inch and .0035 inch. A good straight edge and a .0015 inch feeler blade should be used as a "go" gage and a .004 inch feeler be used as "no go" gage. Too little end clearance will possibly result in a severe failure due to the lack of an oil film between the rotor set and the adjacent surfaces. Too great an end clearance will result in a low flow or weak pump. Housing and rotor faces must be flat and smooth when checking this clearance.

(9) The tooth clearance between the inner and outer rotors must be less than .008 inch. This clearance can be measured with standard feeler gages. The clearance between the O.D. of the outer rotor and the I. D. of the rotor cavity bushing should be between .004 inch and .008 inch; this clearance is also measured with standard feeler gages.

(10) The inner and outer rotors are sold in pairs only; therefore, if either rotor is damaged, both rotors must be replaced.

(11) The flow control valve and pressure relief valve are serviced as an assembly only; therefore, if either valve is damaged, both must be replaced.

(12) The flow control valve spring should be replaced when a load of less than 16 lbs will compress the spring to a 1.20 inch dimension.

(13) If the serrations in the drive hubs are peened and worn, or the teeth of the drive coupling are worn or chipped, replace the drive hubs and coupling.

d. Reassembly.

(1) Pumps are built for right-hand and left-hand rotation depending on the engine model on which they are used. The direction of rotation is marked on the pump body. The pump body for the left-hand pump, from outward appearances, is the same as the right-hand pump body. Similarly, the left-hand and right-hand pump covers appear alike. The difference between the pump bodies as well as the pump covers is in the location of the oil seal bleed hole which must always be in the intake port. When rebuilding pumps particular attention should be directed to the location of the bleed hole because its position and the assembled position of the flow control and relief valve assembly determines the direction of flow through the pump (fig. 3-40).

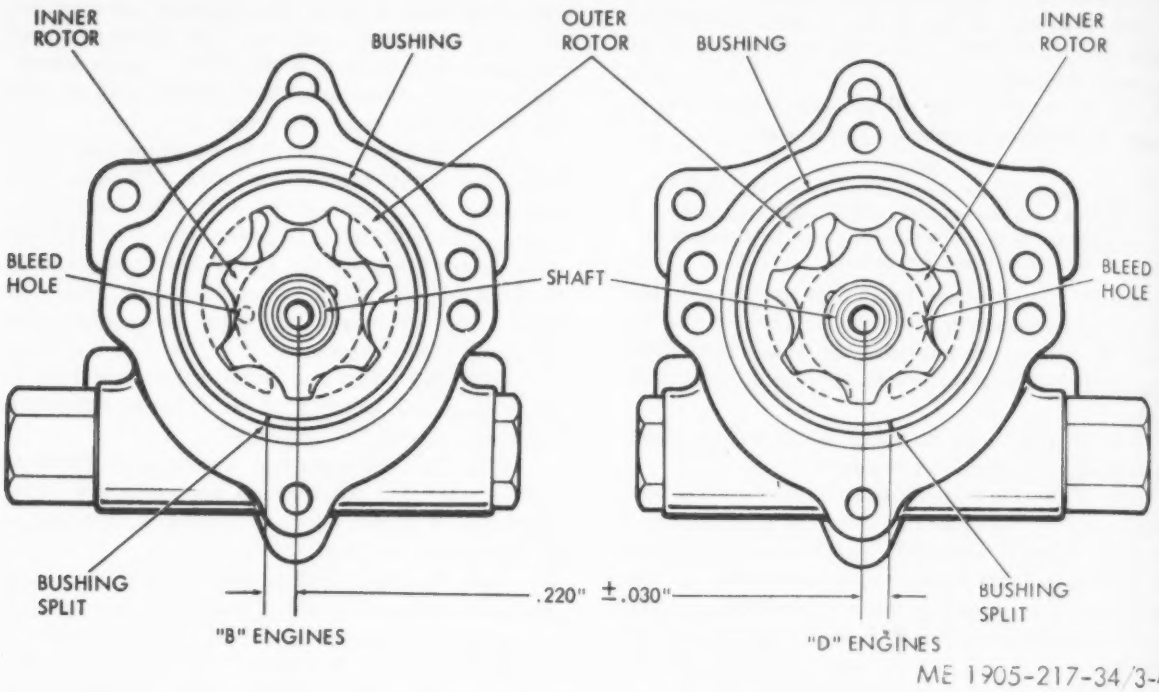


Figure 3-40. Oil pump porting and rotors including bleed holes.

NOTE

When installing the rotor bushing (20, fig. 3-39) in the oil pump body, refer to figure 3-40 for the proper location of the split in the bushing for "B" or "D" engine oil pumps. The outboard engine of the port propulsion unit and the inboard engine of the starboard propulsion unit are "B" engines. The inboard engine of the port propulsion unit and the outboard engine of the starboard propulsion unit are "D" engines.

(2) Refer to figure 3-39 and reassemble the oil pump.

(3) After the bushing (11, fig. 3-39) is installed in the oil pump cover, open the bleed hole in the cover with a 1/8 inch drill, entering from the rotor side of the cover.

(4) Tighten cover to body bolts to 30-35 ft-lb torque.

(5) Install the oil pump drive shaft oil seals (28) in the oil pump body as follows:

(a) Place the oil seal gasket (2) over the end of the shaft and into the oil seal bore in the body.

(b) Place an oil seal over the tapered end of the oil seal protector J 6904-2 with the lip of the oil seal facing down, (fig. 3-41).

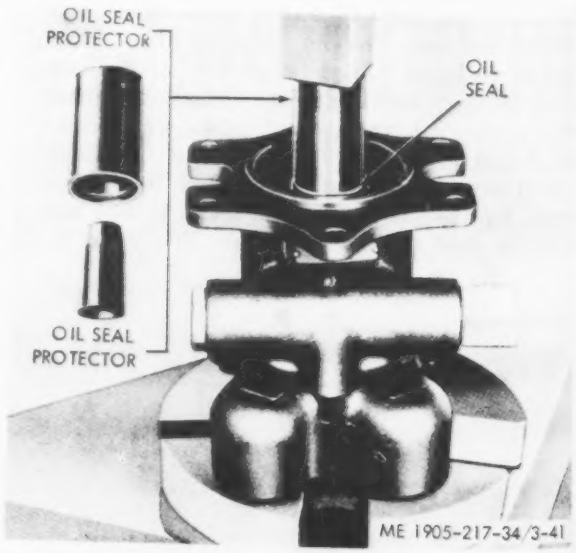


Figure 3-41. Installing oil seals in pump body.

NOTE

The lip of the inner oil seal faces the rotors when installed in the body.

(c) Apply a thin coat of sealing compound he outside diameter of the oil seal casing.

(d) Place the oil seal lip protector with the seal over the end of the oil pump drive shaft. en, slide the oil seal down over the protector against the pump body.

(e) Place the oil seal installer J 6904-3 over oil seal lip protector J 6904-2 and rest on the seal.

(f) Bring the ram of the press down on the taller and press the oil seal straight into the np body until the installer contacts the top of oil seal lip protector.

(g) Place the second oil seal over the ered end of the oil seal lip protector J 6904-2 h the lip of the oil seal facing up.

NOTE

The lip of the outer oil seal points away from the rotors when installed in the body.

(h) Place the oil seal lip protector with oil over the end of the oil pump drive shaft. en, slide the oil seal down over the protector against the pump body.

(i) Place the oil seal installer over the top he oil seal lip protector and rest on the oil seal.

(j) Bring the ram of the press down on the installer and press the oil seals into the pump body until inner oil seal rests on the gasket.

e. Installation. Install the transmission oil pump (TM 55-1905-217-12, para 4-70).

3-12. Power Take-Off Assembly

a. General. The outboard engine of each propulsion unit is equipped with a front mounted power take-off to drive the hydraulic pumps for the ramp hoist system. Each power take-off includes a lever operated clutch. A front end power take-off adapter supports the power take-off assembly and surrounds the clutch and drive mechanism. The adapter retains the crankshaft oil seal and is bolted to the engine front end plate and cylinder block.

b. Removal.

(1) Remove coupling guard and ramp hoist pump, (TM 55-1905-217-12, para 4-84).

(2) Disconnect hoses from engine oil filter and remove filter, (TM 55-1905-217-12, para 4-24).

(3) Support the weight of the power take-off assembly with a rope sling and chain hoist. Engage the clutch with the hand lever to hold the clutch facing in place.

(4) Remove the bolts and lockwashers (fig. 3-42) securing the power take-off assembly to the front end power take-off adapter.

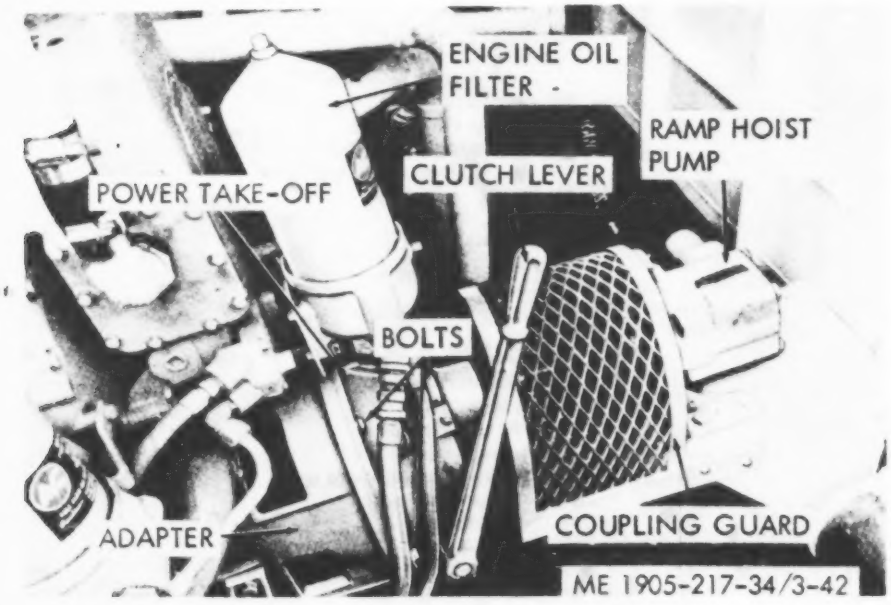


Figure 3-42. Power take-off, removal and installation.

(5) Screw two of the clutch housing at- hing bolts into the tapped holes provided in flange of the clutch housing and push the power take-off assembly away from the front end power take-off adapter. Pull the power take-off assembly straight back away from the engine.

NOTE

Do not permit the outer end of the unit to tip down when being removed from the engine or the clutch pilot bearing may be damaged.

c. Disassembly. Refer to figure 3-43 and disassemble the power take-off clutch.

Key to figure 3-43.

1. Lock washer
2. Driving ring bolt
3. Spring lock
4. Lock washer
5. Screw
6. Flexible tube assembly
7. Bolt
8. Lock washer
9. Lock plate
10. Retainer
11. Key
12. Clutch drive shaft
13. Key
14. Clutch release yoke
15. Grease fitting
16. Clutch housing
17. Gasket
18. Cover
19. Screw
20. Clutch hand lever
21. Bolt
22. Lock washer
23. Grease fitting
24. Nut
25. Bolt
26. Lock washer
27. Clutch release shaft
28. Woodruff key
29. Lockwasher
30. Bolt
31. Outer bearing assembly
32. Bearing cone
33. Bearing cup
34. Inner bearing assembly
35. Clutch release sleeve and collar
36. Pin
37. Link
38. Retaining ring
39. Bolt
40. Collar
41. Clutch release sleeve
42. Nut
43. Release lever spring
44. Adjusting ring wear plate
45. Adjusting ring
46. Inner pressure plate
47. Clutch facing
48. Pressure plate separator spring
49. Outer pressure plate
50. Retaining ring
51. Release lever
52. Pin
53. Clutch driving ring
54. Lockwasher
55. Nut

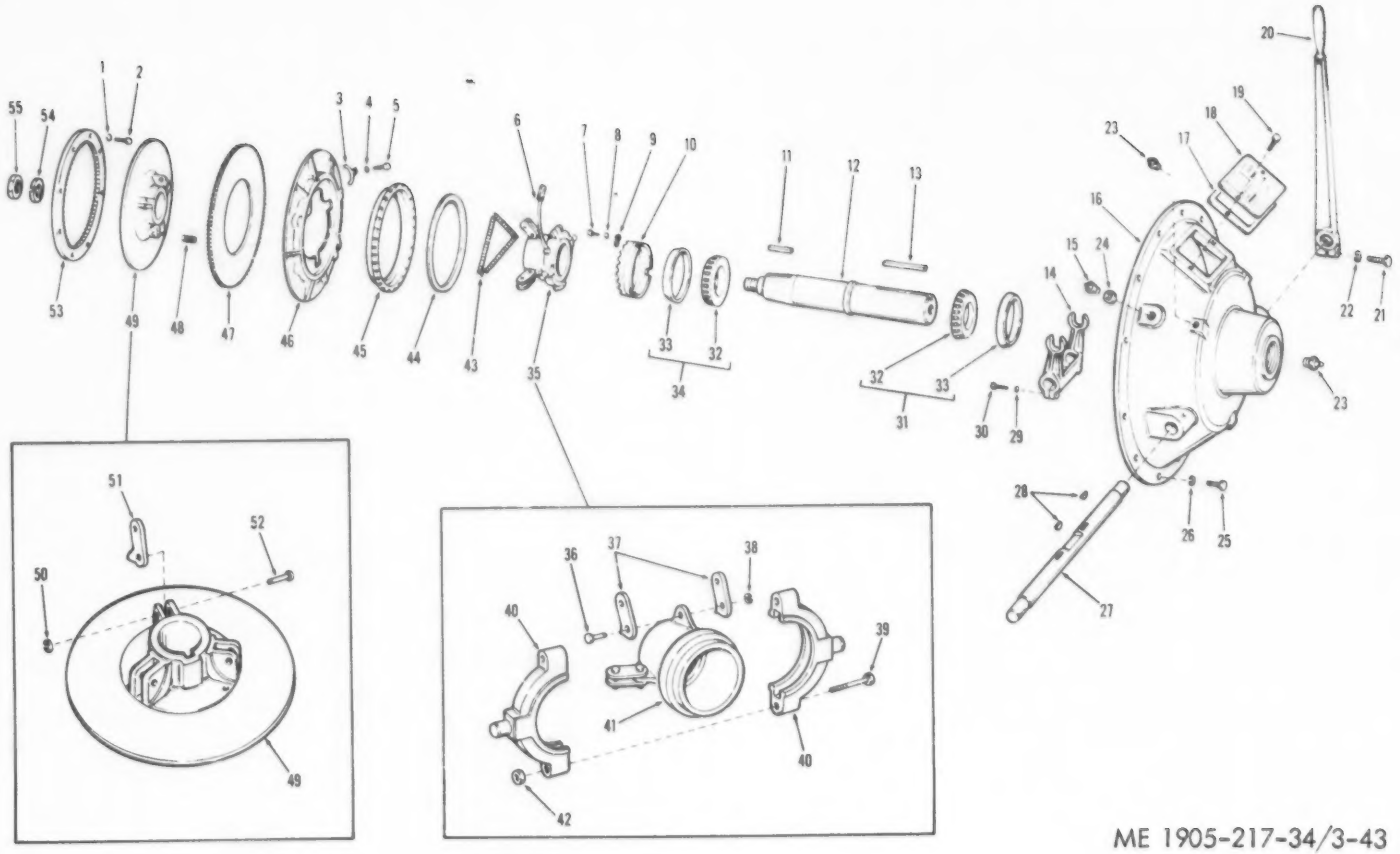


Figure 3-43. Power take-off clutch, disassembly and reassembly.

d. Cleaning, Inspection, and Repair.

(1) Wash all of the power take-off parts except the clutch facings in solvent, (FED. SPEC. PD-680) then, dry them with compressed air.

(2) Examine the bearings for corrosion and pitting. Lubricate each bearing with light engine oil, then, while holding the inner race or cone from turning, revolve the outer race or cup slowly by hand and check for rough spots.

(3) Examine the clutch facing for wear, burning or scoring. Also, check the teeth for wear or damage and measure the thickness of the facing. Replace the clutch facing if the teeth are worn or damaged, or if the facing is badly burned, scored or worn to the approximate worn thickness of ¼ inch minimum.

(4) Inspect the friction surfaces of the clutch pressure plates for being flat, smooth and free from cracks or heat checks. Also, examine the drive bosses, the keyway in the outer pressure plate, the adjusting ring threads and the notches in the inner pressure plate.

(5) Examine all of the release levers, link pins and pin holes in the links, release levers, release sleeve and pressure plate for wear.

(6) Inspect the clutch adjusting ring wear plate (44, fig. 3-43) and the ring threads for wear. If the wear plate is worn excessively, reverse the plate. If both sides of the plate are worn, replace it.

(7) Examine the wear surface of the clutch release sleeve collar and the mating surface on the release sleeve for wear and scoring.

(8) Inspect the mating surface of the clutch release yoke fingers and mating trunnions on the release sleeve collar for wear.

(9) Check for weak or broken pressure plate separator springs (48). Check the spring load on the springs with a spring tester. The approximate free length is 7/8 inch and the approximate outside diameter is 3/8 inch. Springs should be replaced when force exerted is less than 12-15 lbs. at 5/8 inch length.

e. Reassembly.

(1) Refer to figure 3-43 and reassemble the clutch.

(2) Attach the clutch driving ring (53) to the power take-off adapter with bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

(3) Tighten the drive shaft nut (55) to 165-160 lb-ft torque.

f. Installation.

(1) Support the power take-off assembly with a rope sling and chain hoist, then position the power take-off assembly at the adapter with the clutch drive shaft in line with the pilot bearing in the coupling and flange assembly.

(2) Push the power take-off toward engine and guide the end of the drive shaft straight into the clutch pilot bearing and engage the teeth on the outer diameter of the clutch facing with the teeth in the inner diameter of the driving ring.

(3) Guide the pilot on the clutch housing straight into the front end adapter opening, then install the clutch housing to adapter bolts and lockwashers. Tighten the bolts to 30-35 lb-ft.

g. Clutch Adjustment. Adjust the clutch (TM 55-1905-217-12, para 4-84).

Section II. ENGINE COMPONENTS AND TRANSMISSION

3-13. Cylinder Head, and Injector Control Tube

a. Removal.

(1) Drain the cooling system to a level below the head. (TM 55-1905-217-12, para 4-22).

(2) Remove the exhaust pipe and water connections from the manifolds (TM 55-1905-217-12, para 4-22).

(3) Remove Rocker arm cover (TM 55-1905-217-12).

(4) Slide thermostat housing clamp and packing back on water manifold. Remove thermostat and housing (TM 55-1905-217-12, para 4-44).

(5) Loosen the injector control tube bracket bolts as shown in figure 3-44. Lift control tube up and away from head.

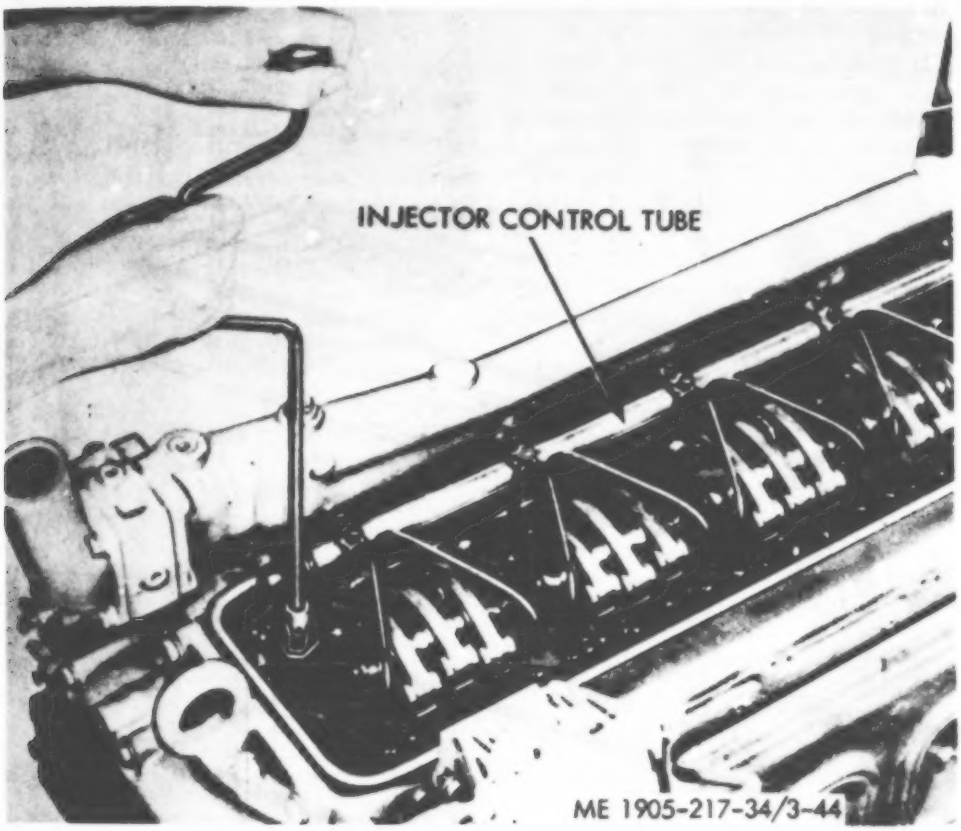


Figure 3-44. Injector control tube and cylinder head mounting nuts and bolts, removal and installation.

(6) Remove fuel injectors and connectors para 3-4).

(7) Remove the governor assembly (para 3-).

(8) Loosen the two bolts directly below each ifter bracket which attach the balance weight over and flywheel housing to the front and rear nd plates.

(9) Remove the four bolts that secure the ifter brackets to the balance weight cover and lywheel housing.

(10) Remove the cylinder head mounting uts and bolts as shown in figure 3-44.

(11) Insert lifting hooks into the lifting racket eyes and, with a hoist, lift the cylinder ead evenly off the cylinder head studs.

CAUTION

Do not set the cylinder head with the bottom face down on bench as this will damage the cam followers and injector spray tips will be damaged.

b. Disassembly. If a cylinder head was removed for inspection and possible repair or replacement, remove the following parts:

(1) Fuel injectors, if not already removed. Refer to TM 55-1905-217-12, paragraph 4-28, for removal.

(2) Fuel oil connectors. Refer to TM 55-1905-217-12, paragraph 4-28 for removal.

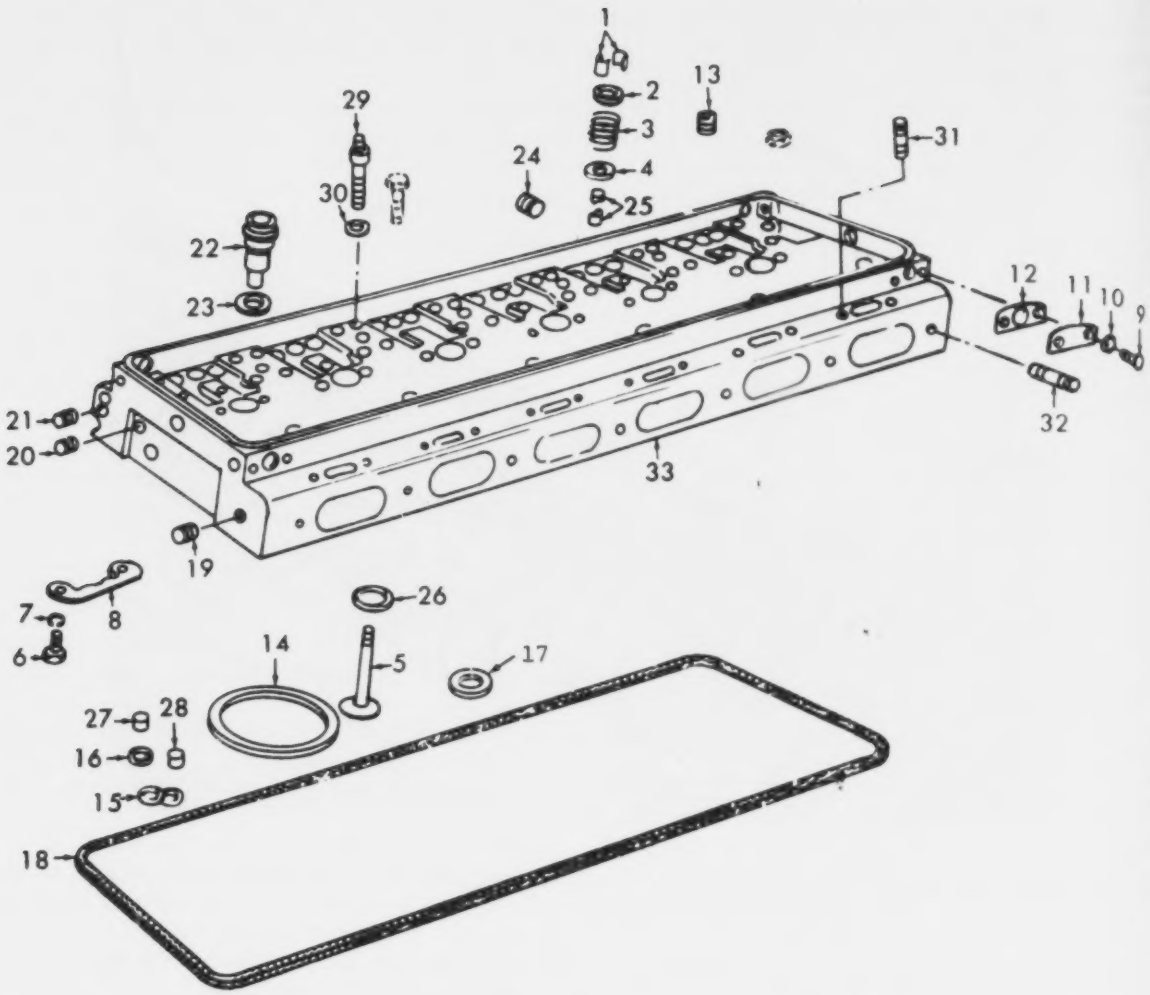
(3) Valve and injector rocker arms (para 3-14).

(4) Cam followers, spring retainers, push rods, and springs (para 3-14).

(5) Valves and valve springs (para 3-15).

(6) Water manifold. Refer to TM 55-1905-217-12, paragraph 4-43, for removal.

(7) Remove the valve spring locks (1, fig. 3-45), retainers (2), springs (3), shouldered washer (4), and valves (5) from the head.



TS 1905-217-34/3-45

1. Valve spring locks
2. Retainer
3. Spring
4. Washer
5. Valve, poppet
6. Screw
7. Lock washer
8. Guide, cam follower
9. Screw
10. Lockwasher
11. Cover, governor
12. Gasket
13. Plug, pipe
14. Gasket
15. Gasket
16. Washer
17. Gasket
18. Gasket
19. Plug
20. Plug
21. Plug
22. Tube, injector hole
23. Preformed packing
24. Plug, pipe
25. Valve guide
26. Valve seat insert
27. Nozzle, water
28. Nozzle, water
29. Connector, fuel line
30. Flat washer
31. Stud, water manifold
32. Stud, exhaust manifold
33. Cylinder head

Figure 3-45. Cylinder head and valves, disassembly and reassembly.

ey to figure 3-45.
. Valve spring locks
. Retainer
. Spring
. Washer
. Valve, poppet
. Screw
. Lockwasher
. Guide, cam follower
. Screw
. Lockwasher
. Cover, governor
. Gasket
. Plug, pipe
. Gasket
. Gasket
. Washer
17. Gasket
18. Gasket
19. Plug
20. Plug
21. Plug
22. Tube, injector hole
23. Preformed packing
24. Plug, pipe
25. Valve guide
26. Valve seat insert
27. Nozzle, water
28. Nozzle, water
29. Connector, fuel line
30. Flat washer
31. Stud, water manifold
32. Stud, exhaust manifold

(8) Remove the screws (6), lockwashers (7), and cam follower guides (8) from the head.

(9) Remove the screws (9), lockwashers (10), governor covers (11), and gaskets (12).

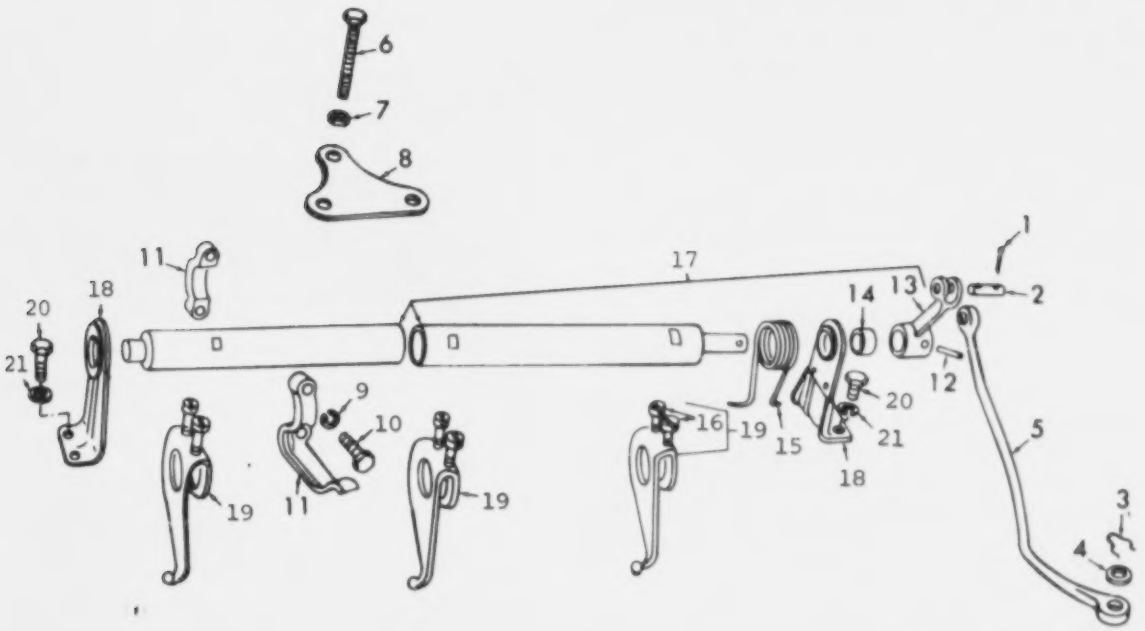
(10) Remove the pipe plugs (13), oil ring gaskets (14), water hole gaskets (15), nonmetallic washers (16), compression gaskets (17), and water gaskets (18) from the head.

(11) Remove the slotted head machine plugs (19, 20, 21), injector hole tube (22), preformed packing (23), and pipe plug (24) from head.

(12) Remove the valve guides (25) and valve seat inserts (26).

(13) Remove the water nozzles (27 and 28), fuel line connectors (29), flat washers (30), and studs (31 and 32) from the head.

(14) Remove the cotter pins (1, fig. 3-46), straight headless pin (2), retainer (3), flat washers (4), and remove the governor control links (5).



TS 1905-217-34/3-46

1. Cotter pin
2. Pin, straight headless
3. Retainer
4. Flat washer
5. Link, governor control
6. Bolt
7. Nut, adjusting
8. Plate, injector
9. Lock washer
10. Capscrew
11. Injector arm
12. Pin, grooved
13. Arm lever
14. Sleeve spacer
15. Spring
16. Screw
17. Injector control tube
18. Support bracket
19. Lever
20. Capscrew
21. Lockwasher

Figure 3-46. Injector control tube assembly, disassembly and reassembly.

best copy available

(15) Remove the load limit bolts (6), adjusting nuts (7), and injector plates (8).

(16) Remove capscrews (20), lockwashers (21) and remove injector control tube assembly.

(17) Remove the capscrews (9), lockwashers (10) and injector arms (11) from the control tube.

(18) Remove the grooved pins (12) and remove arm lever (13). Remove sleeve spacers (14) from the arm levers. Remove the springs (15).

(19) Loosen lever screws (16) and remove control tube (17) from levers. Remove levers (19) from rack.

c. Cleaning. After the cylinder head has been stripped of all its component parts and all of the plugs have been removed, steam clean the head thoroughly. If the water passages have been heavily scaled, remove the copper injector tubes and water nozzles and clean the cylinder head as follows:

(1) Scrape all gasket material from the cylinder head.

(2) If a core hole plug is difficult to remove, hold a 3/4 inch drift against the plug and give it a few sharp blows with a one-pound hammer. With a 1/2 inch flexible handle and a short extension place in the countersunk hole in the plug, turn the plug slightly in the direction of tightening. Then, turn it in the opposite direction and back the plug out.

(3) Remove the grease by agitating the cylinder head in a hot bath of heavy-duty alkaline solution.

(4) Wash the block in hot water or steam clean it to remove the alkaline solution.

(5) If the water jackets are heavily scaled, proceed as follows:

(a) Agitate the head in a bath of inhibited commercial pickling acid.

(b) Allow the head to remain in the acid bath until the bubbling action stops (approximately 30 minutes).

(c) Lift the head, drain it, and reimmerse it in the same acid solution for 10 minutes.

(d) Repeat step "c" until all scale is removed.

(e) Rinse the head in clear hot water to remove the acid solution.

(f) Neutralize the acid that may cling to the casting by immersing the head in an alkaline bath.

(g) Wash the head in clean water or steam clean it.

(6) Make certain that all water passages and oil galleries have been thoroughly cleaned.

NOTE

The above cleaning procedure may be used on all ordinary cast iron and steel parts of the engine. Mention will be made of special cleaning procedures whenever necessary.

(7) After cleaning, dry the cylinder head with compressed air.

d. Inspection and Repair. Over a prolonged period of operation, the cylinder head may assume a contour to match that of the cylinder block, which is normal. However, if the cylinder head is allowed to become overheated because of coolant loss, the resultant high temperatures cause stresses to occur in the casting which will affect the flatness of the head. Therefore, check the bottom (fire deck) of the cylinder head for flatness as follows:

(1) Use a heavy, accurate straight-edge and feeler gage to check for transverse warpage at each end and between all cylinders. Also, check for longitudinal warpage in six places as shown in figure 3-47. Maximum allowable warpage is given by the following:

Maximum Longitudinal Warpage	*Maximum Transverse Warpage*
.010 inch	.004 inch

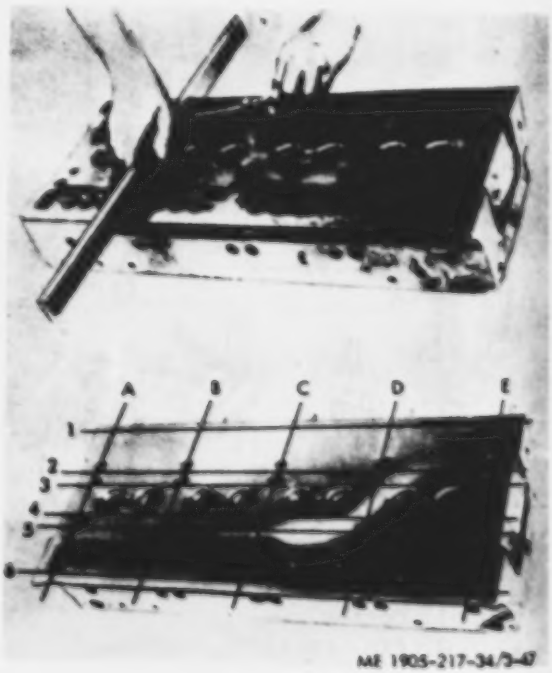
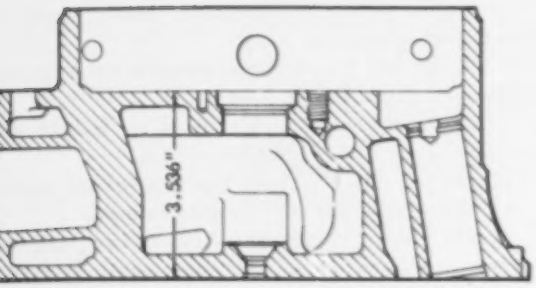


Figure 3-47. Checking bottom face of cylinder head.

(2) Use the maximum allowable warpage limits as a guide in determining the advisability of reinstalling the head on the engine or of refacing it. The number of times a cylinder head may be refaced will, of course, depend upon the amount of stock removed from the head during previous reworking operations.

(a) When refacing a cylinder head, stamp
e amount of stock removed on the face of the
re deck. Do not remove over .020 inch of metal
om the fire deck of any cylinder head. The
istance from the top deck to the bottom (fire
eck) of the cylinder head must not be less than
536 inch (fig. 3-48).



ME 1905-217-34/3-48

Figure 3-48. Minimum distance between top and bottom faces of cylinder head.

(b) When a cylinder head has been refaced,
heck and correct the critical dimensions such as
he protrusion of the valve inserts, valves, in-
ctor tubes, and injector spray tips from the fire
eck. Adjust the push rod length also in order to
revent the valves from striking the top of the
iston when the head is reinstalled on the engine.

(3) Check the cylinder head for leaks and
racks as follows:

(a) Seal off the water holes in the head by
sing steel plates and suitable rubber gaskets
lamped in place by bolts.

(b) Install scrap or dummy injectors to
nsure seating of the injector tubes. Dummy
njectors may be made up with old injector nuts
nd bodies—the injector spray tip is not
ecessary. Tighten the injector clamp nuts or
olts to 20-25 lb-ft torque.

(c) Drill and tap into one of the water hole
over plates for an air hose connection and apply
0-100 psi air pressure to the water jacket. Then,
nmerse the head in a tank of water previously
eated to 180°-200°F. for about fifteen to twenty
inutes to thoroughly heat the cylinder head.
eaks will be detected by noting any air bubbles
hich may appear in the water. Check for leaks at
he bottom and top of the injector tubes, oil
allery, cylinder head stud holes, exhaust ports,
nd the top, bottom and sides of the head itself.

(d) Relieve the air pressure, remove the cylinder head from the water tank, remove the water hole plates and gaskets, and dry the cylinder head with compressed air. Replace any leaking injector tubes. If inspection revealed any cracks, replace the cylinder head.

(4) Install new injector tubes if the old tubes leaked or the cylinder head was refaced.

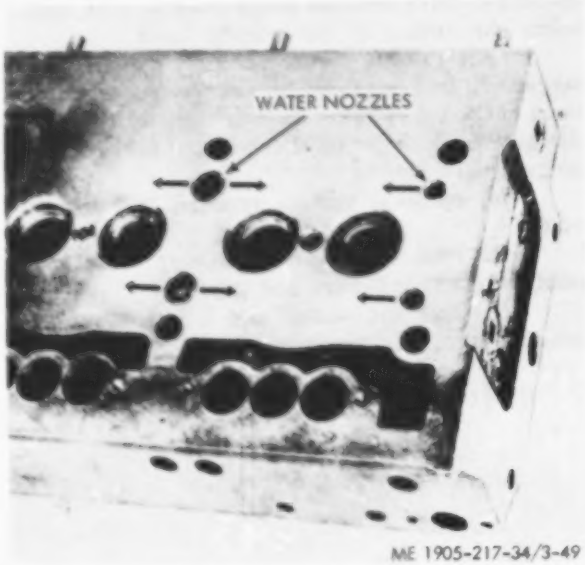
(5) Check the valve seat inserts for cracks or burning. Also, check the valve guides for scoring.

(6) Inspect the cam follower bores in the cylinder head for scoring or wear. Light score marks may be cleaned up with crocus cloth wet with fuel oil. The inside diameter of the bores are 1.062 inches to 1.063 inches in a new cylinder head (1.065 inches maximum on a used head). If the bores are excessively scored or worn so that the cam follower-to-head clearance exceeds .006 inches, reject the cylinder head.

(7) Check the cylinder head water nozzles for looseness. Install or replace the cylinder head water nozzles as follows:

(a) Be sure that the water inlet ports in the bottom of the head are clean and free of scale. The water holes at each end of the head may be cleaned up with ⅛ inch drill and all of the other water holes may be cleaned up with a 13/16 inch drill. Break the edges of the holes slightly.

(b) Press the nozzles in place with the nozzle openings parallel to the longitudinal center line of the cylinder head. Install the ½ inch diameter nozzles at the ends of the cylinder head with their openings toward the center of the engine (fig. 3-49).



ME 1905-217-34/3-49

Figure 3-49. Correct installation of water nozzles in cylinder head.

(c) Install the nozzles flush to 1/32 inch below (recessed) the bottom surface of the cylinder head; otherwise, interference with proper seating of the head on the cylinder block may be encountered.

(d) Check to make sure the nozzles fit tight in the cylinder head. If the water holes have been enlarged by corrosion, expand the nozzles by means of a wood plug or other suitable tool, or tin the outside diameter with solder to provide a tight fit. If solder is used, exercise care so that the orifices in the nozzles are not closed with solder.

(8) Replace a cylinder head that is damaged beyond repair.

e. Reassembly.

(1) The service replacement cylinder head assemblies incorporate fuel inlet and outlet manifolds which are cast interrally with the head. The head assemblies include the water and exhaust manifold studs, water inserts, all of the necessary plugs, and assembly instructions. Fuel pipe connectors and washers, a length of flexible fuel hose and fittings, and a restricted fitting are also included.

(2) Injector clamp bolts to studs are not included and it is necessary to use new parts or transfer the old parts to the new cylinder head.

(3) After cleaning and inspection, install the required plugs in the cylinder head. Apply a small amount of "dual purpose" sealer to the threads of the pipe plugs only. Work the sealer into the threads and wipe off the excess with a clean, lint-free cloth so that the sealer will not be washed into the fuel or oil passages. Install and tighten the plugs. Drive headless plugs flush to 1/16 inch below the surface of the cylinder head.

(4) After the following parts are cleaned and inspected, and replaced if necessary, reinstall them in the old cylinder head or transfer them to the new head. Refer to chapter one, table 5, for torque requirements.

(a) Exhaust valves, springs, and spring seats.

(b) Push rods, springs, spring seats and retainers, cam followers and guides.

(c) Exhaust valve and injector rocker arms, shafts, and brackets.

(d) Fuel injectors.

(e) Fuel oil manifolds (if separate manifolds are used), fuel pipes, and fuel pipe connectors.

NOTE

If a new cylinder head is used, the new shorter fuel pipe connectors and sealing washers must be used and the old fuel manifolds discarded.

f. Pre-Installation Inspection. The following inspections shall be made just prior to installing the cylinder head onto the engine. Make these inspections regardless of whether the head was removed from the engine for servicing only the head assembly or to facilitate other repairs to the engine.

(1) Check the cylinder head studs for damaged threads.

(2) Check for extruded areas around the stud holes in the cylinder block.

(3) Check the cylinder liner height with relationship to the cylinder block.

(4) Check to be sure the tops of the pistons are clean and free of foreign material.

(5) Check to see that ALL of the push rods are threaded into their clevises until the ends of the push rods project through the clevises. This is important since serious engine damage will be prevented when the engine is cranked or barred-over during tune-up.

(6) Check the cylinder block and cylinder head gasket surfaces and counterbores to ascertain that these sealing surfaces are clean and free from foreign material. Also check to ensure that there are no burrs or sharp edges in the counterbores.

(7) Check the four corner plugs or drive pins used to plug the vertical oil galleries to ensure that they are flush with, or below, the top surface of the cylinder block.

g. Installation. Install the cylinder head in reverse order of removal (a) above.

3-14. Rocker Arms, Cam Followers, and Push Rods

a. Rocker Arms and Shaft.

(1) *Removal.*

(a) Remove the cylinder head (para. 3-13).

(b) Disconnect and remove fuel pipes from injector and fuel connectors (TM 55-1905-217-12).

(c) Remove the two bolts that hold the rocker arm shaft brackets to the head. Remove brackets and shaft as shown in figures 3-50 and 3-51.

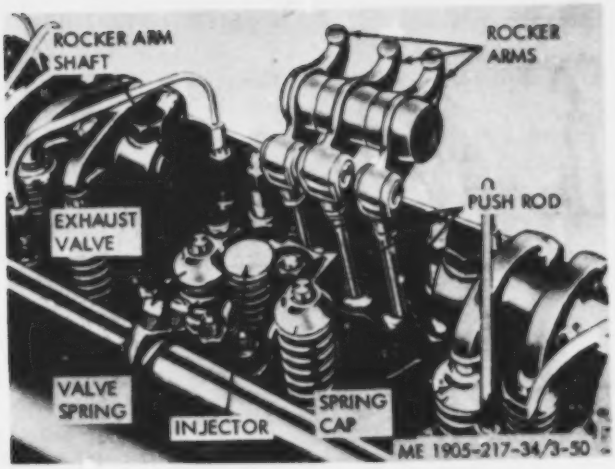


Figure 3-50. Rocker arm and shaft, removal and installation.

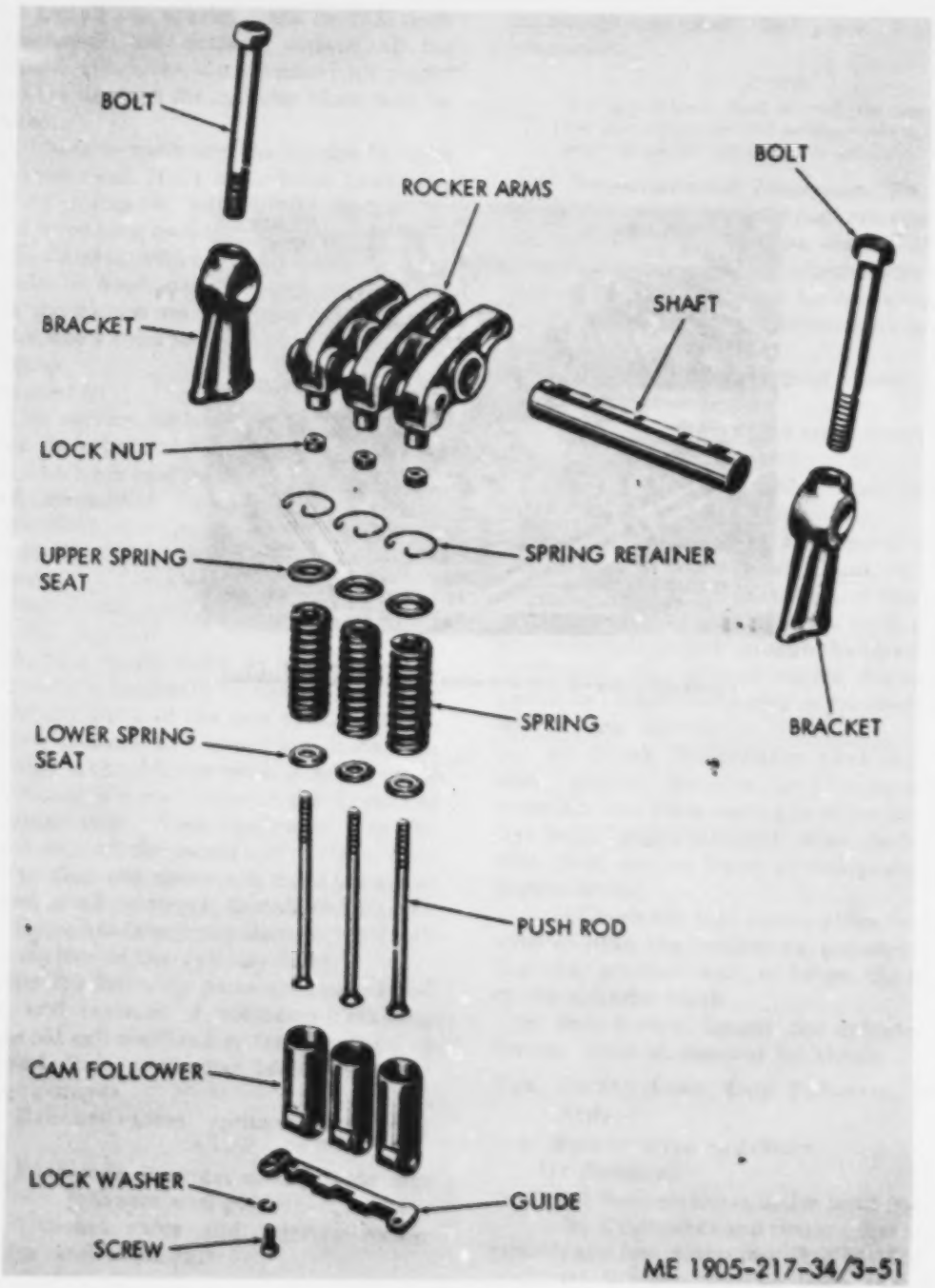


Figure 3-51. Rocker arms, cam followers, and push rods, disassembly and reassembly.

CAUTION

When removing the rocker arm shaft, fold back the three rocker arms just far enough so that the shaft may be removed. Do not force the rocker arms all the way back with the shaft in place as this may impose a load that could bend the push rods.

(d) Loosen the locknut at the upper end of the push rod (fig. 3-51), next to the clevis and unscrew the rocker arm from the push rod. Remove all rocker arms in the same manner.

(2) *Cleaning and Inspection.*

(a) Clean out the oil passages in the rocker rms, bracket bolts and rocker arm shafts with uel oil and a small wire and dry them with ompressed air. It is very important to inspect he rocker arm shaft bolts for plugged oil assages.

(b) Inspect the rocker arm shaft and the ushings inside of the rocker arms for excessive ear. The diameter of a rocker arm shaft is .8735 nch to .8740 inch, and the inside diameter of a ocket arm bushing is .8750 inch to .8760 inch. Thus, the clearance is .001 inch to .0025 inch. A naximum clearance of .004 inch is allowable with sed parts. Service replacement bushings must be eamed to size after installation.

(c) Inspect the rocker arms for wear or galling on the pallets (valve contact surfaces). If worn, the pallets may be refaced to a maximum depth of .010 inch. However, proceed with caution when surface grinding so that the rocker arms are not overheated. Maintain the radius and finish as close to the original surface as possible.

(3) *Repairs.* Replace a defective rocker arm and shaft.

(4) *Installation.* Install the rocker arm and shafts in reverse order of removal ((1) above).

b. Cam Follower and Push Rod Assemblies.

(1) *Removal.*

(a) Rest the cylinder head on its side, as shown in figure 3-52, and remove the two bolts that secure the cam follower guide to the cylinder head. Remove the guide.

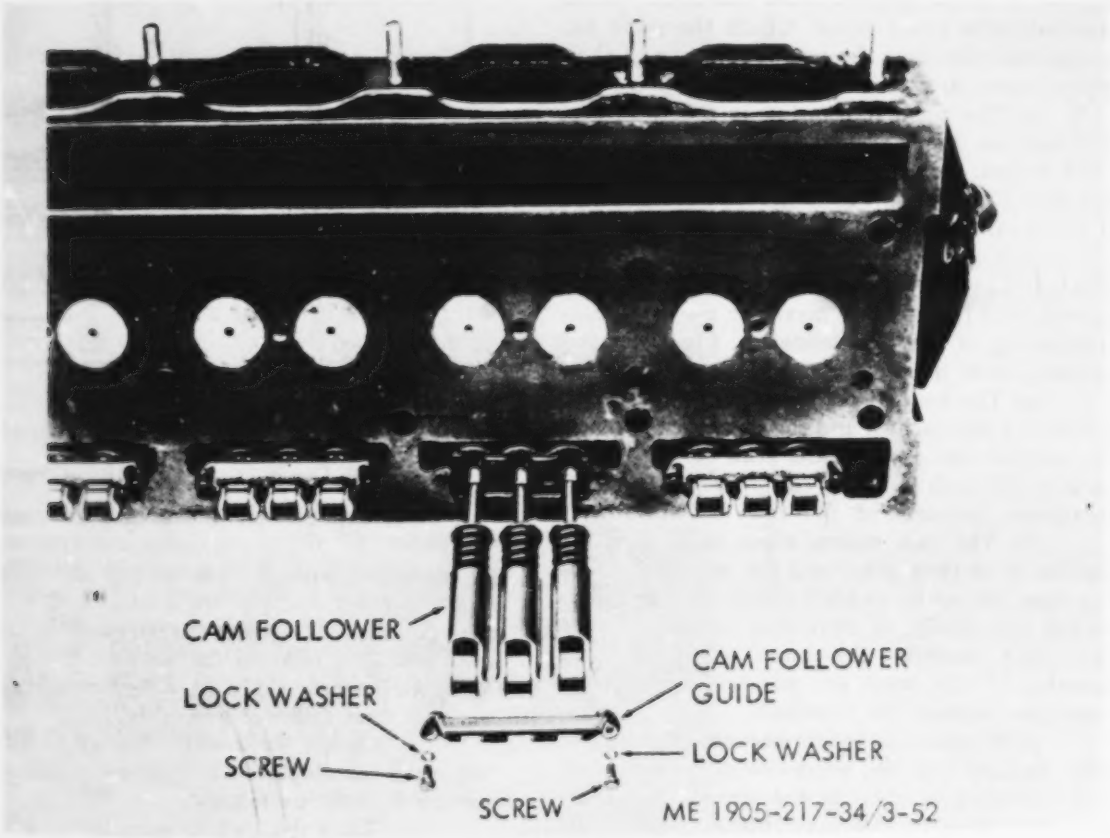


Figure 3-52. Cam follower and guide, removal and installation.

(b) Pull the cam follower from the bottom f the cylinder head.

(c) Remove the fuel lines from the injector nd the fuel connectors.

(d) Loosen the push rod lock nut and nscrew the push rod from the rocker arm clevis.

(e) Pull the push rod and spring assembly from the bottom of the cylinder head.

(f) Remove the push rod lock nut, upper spring seat, spring, and lower spring seat from the push rod for cleaning and inspection (fig. 3-51).

NOTE

The push rod spring seat retainer remains in the cylinder head.

(2) *Cleaning and Inspection.*

(a) When any appreciable change in the injector timing or exhaust valve clearance occurs during engine operation, remove the cam followers and their related parts and inspect them for excessive wear. This change in the injector timing or valve clearance during engine operation can usually be detected by excessive noise at idle speed.

(b) After the cam followers and their associated parts are removed, clean all of the parts thoroughly with solvent FED. SPEC. PD-680, and dry them with compressed air.

(c) Inspect the push rods and push rod spring seats for wear.

(d) The purpose of a push rod spring is to maintain a predetermined load on the cam follower to insure contact of the cam roller on the camshaft lobe at all times. Check the push rod spring load whenever the cam followers and their related parts are removed for inspection.

(e) The push rod spring is made of wire .177 inch in diameter and has a free length of 2 5/8 inches. Replace the spring when a load of less then 172 pounds will compress it to a length of 2 1/8 inches.

(f) Examine the cam follower bores in the cylinder head to make sure they are clean, smooth, and free of score marks to permit proper functioning of the cam followers. Clean up any existing score marks.

(g) The diameter of a cam follower is 1.060 inches to 1.061 inches, and the clearance between the cam follower and cylinder head bore with new parts is .001 inch to .003 inch. With used parts, a maximum clearance of .006 inch is allowable.

(h) The cam rollers must turn smoothly and freely on their pins, and the rollers must be free from flat spots or scuff marks. If the rollers do not turn freely, or have been scored or worn flat, then examine the cams on which they operate. If the cams are excessively worn or damaged, replace the camshaft.

(i) Measure the total clearance between the roller bushing and pin, crosswise of the pin, and, if the bushing is worn to the extent that more than .010 diametric clearance exists, install a new cam roller and pin, which are serviced as a set, in the follower assembly. Also, check the total side clearance between the roller and follower; this clearance must be .015 inch to .023 inch (fig. 3-53).

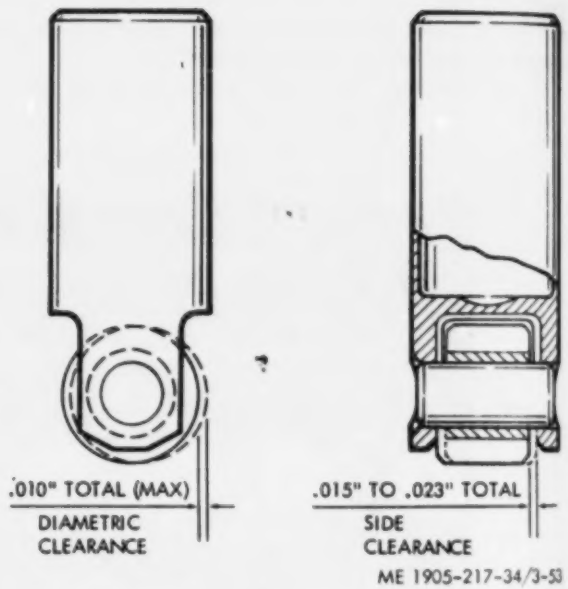


Figure 3-53. Cam roller wear and clearance diagram.

(j) Cam followers that are stamped with the letter "S" on the pin, roller and follower body are equipped with an oversize pin and roller. An oversize roller and pin are available as a set for service. DO NOT attempt to bore out the legs of a standard cam follower for an oversize pin. The same clearances apply to either a standard or oversize cam follower assembly.

(3) Cam Follower Roller and Pin Replacement. Replace a cam follower roller, using fixture J 5840, as follows:

(a) Lock the fixture securely in a vise as shown in figure 3-54. Then, place the cam follower in the groove in the top of the fixture with the follower pin resting on top of the corresponding size plunger in the fixture.

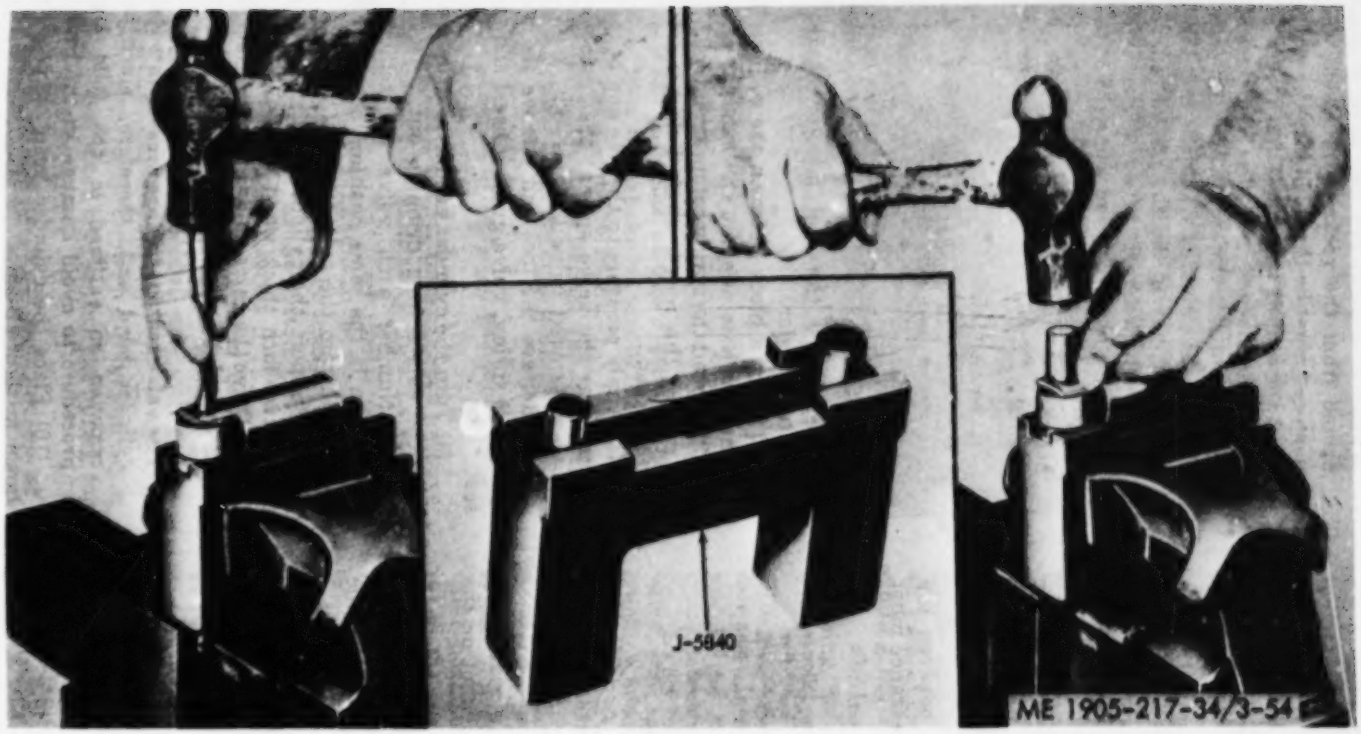


Figure 3-54. Cam follower, roller, and pin, removal and installation.

(b) With a suitable drift, drive the pin from the roller. Exercise caution in removing the cam follower body and roller from the fixture as the follower pin is seated on top of a spring loaded plunger in the fixture body. Prior to installing a new roller and pin, remove any burrs on the surfaces of the cam follower at the pin holes.

(c) Position the follower body in the groove of the fixture with the proper size plunger extending through the roller pin hole in one of the legs of the follower body. Coat the roller bushing and roller pin with engine oil.

(d) Install the roller in position in the cam roller body. The plunger, when released, will extend into the roller bushing and assure accurate alignment of the bushing with the roller pin holes in the follower body.

(e) Start the roller pin squarely into the follower. Then, carefully drive the pin into the assembly until the pin is centered in the legs of the follower (fig. 3-54).

(f) Check the side clearance between the roller and the follower body. This clearance must be .015 inch to .023 inch.

NOTE

Immerse a new or solvent-cleaned cam follower assembly in clean engine oil for at least five minutes before placing it in the cylinder head. This will ensure initial lubrication over the full length of the cam follower roller pin, and is essential to satisfactory cam follower performance. Rotating the cam roller during this period will aid in introduction of oil to the cam roller pin.

(4) *Repair.* Replace damaged or defective cam followers and push rod assemblies as required.

(5) *Installation.*

(a) Assemble the lower spring seat, push rod spring, upper spring seat, and locknut on the push rod (figure 3-51).

(b) With the spring seat retainer in place in the cylinder head, slide the push rod and spring assembly into position from the bottom of the cylinder head (fig. 3-52).

(c) Screw the push rod locknut down on the upper end of the push rod as far as possible; then, screw the push rod into the clevis until the end of the rod is flush with or above the inner side of the clevis.

(d) Lubricate the cam roller and cam follower body.

(e) Note the 1/8 inch oil hole in the bottom of the cam following. With this hole pointing away from the exhaust valves and injectors, so that the hole is not covered by the cam follower guide, slide the cam follower into position from the bottom of the head.

(f) Attach the follower guide to the cylinder head to hold the group of cam followers in place. Check to make sure there is clearance between the cam followers and the cam follower guide. Tighten the guide bolts to 12-15 lb-ft torque.

CAUTION

Whenever a push rod has been disconnected from the rocker arm clevis, the push rod must be threaded into the clevis until the end of the rod is flush with or above the inner side of the clevis yoke at the time of reassembly, before the valve clearance is adjusted. If this is not done, the valve may strike the piston (due to the small clearance between the valve head and the piston head when the piston is at top dead center) and thus be seriously damaged when the crankshaft is turned.

3-15. Exhaust Valves

a. Removal and Disassembly.

NOTE

Do not permit the cylinder head to rest on the cam followers.

(1) Remove the fuel injector of the appropriate cylinder.

(2) Place a block between the cylinder head and the bench to support the exhaust valves.

(3) Thread the spring compressor tool J 7455, into one of the rocker shaft bolt holes in the cylinder head.

(4) Apply pressure to the free end of the tool to compress the valve spring, then remove the two-piece tapered valve lock. (1, fig. 3-45).

(5) Release the tool and remove the spring cap, valve spring, valve guide oil seal and spring seat.

(6) Turn the cylinder head over using care to keep the valves from dripping out.

(7) Number each valve to facilitate reinstallation in the same position, then withdraw the valves from the cylinder head.

(8) Support the cylinder head, bottom side up, on two inch thick wood blocks.

(9) Drive the valve guide out from the bottom of the cylinder head with tool J 267.

CAUTION

The valve seat inserts are pressed into the cylinder head and, therefore, must be removed as outlined in the following procedure to avoid damage to the head.

(10) Place the cylinder head on its side as shown in figure 3-55.

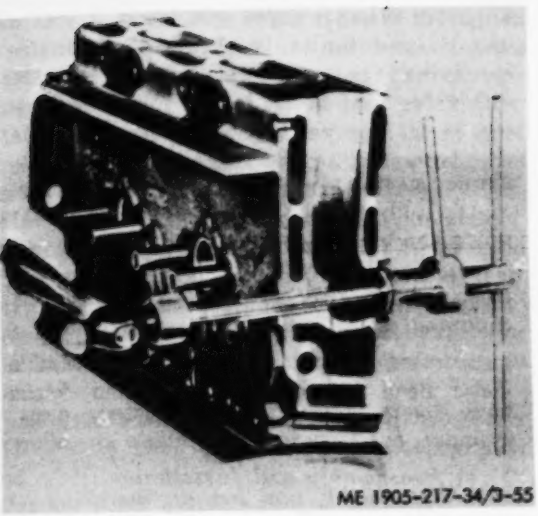


Figure 3-55. Valve seat insert, removal.

(11) Place the collet of tool J 4824-01 inside e valve insert so that the bottom of the collet is sh with bottom of the insert.

(12) Hold the collet handle and turn the T ndle to expand the collet cone until the insert is ld securely by the tool.

(13) Insert the drive bar of the tool through e valve guide.

(14) Tap the drive bar once or twice to move e insert about 1/16 inch away from its seat in e cylinder head.

(15) Turn the T handle to loosen the collet ne and move the tool into the insert slightly so at the narrow flange at the bottom of the collet below the valve seat insert.

(16) Tighten the T handle and continue to ive the insert out of the cylinder head.

b. Cleaning and Inspection.

(1) *Valve Springs.*

(a) Clean the spring with fuel oil and dry it th compressed air. Then inspect the spring for sted or fractured coils.

(b) Use spring tester J 9666 and an accurate torque wrench to check the spring load.

NOTE

The valve springs should be replaced when a load less than 135 pounds will compress the spring to 1 49/64 inches.

(2) *Exhaust Valves.*

(a) Carbon on the face of a valve indicates blowby due to a faulty seat. Black carbon deposits extending from the valve seats to the valve guides may result from cold operation due to light loads or the use of too light a grade of fuel. Rusty brown valve heads with carbon deposits forming narrow collars near the valve guides evidence hot operation due to overloads, inadequate cooling, or improper timing which results in carbonization of the lubricating oil.

(b) Clean the carbon from the valve stems and wash the valves with fuel oil. The valve stems must be free from scratches or scuff marks and the valve faces must be free from ridges, cracks, or pitting. If necessary, reface the valves or install new valves. If the valve heads are warped, replace the valves.

(3) *Exhaust Valve Guides.*

(a) Clean the inside diameter of the valve guides with brush J 5437. This brush will remove all gum or carbon deposits from the guides, including the spiral grooves.

(b) Inspect the valve guides for fractures, chipping, scoring, or excessive wear. Check the valve-to-guide clearance, since worn valve guides may eventually result in improper valve seat contact. If the clearance exceeds .006 inch, replace the valve guides.

(4) *Exhaust Valve Seat Insert.* Inspect the valve seat inserts for excessive wear, pitting, cracking or and improper seat angle. The proper angle for the seating face of both valve and insert is 30°.

c. Reconditioning Valve and Valve Seat.

(1) Reface an exhaust valve which is to be reused, if necessary. The edge of the valve at the valve head must not be less than 1/32 inch in thickness after refacing.

(2) Before installing either a new or used valve, examine the valve seat insert in the cylinder head for proper valve seating. The proper angle for the seating face of both the valve and valve insert is 30°.

(3) The angle of the valve seat insert must be exactly the same as the angle of the valve face so as to provide proper seating of the valve.

(4) When a new valve seat insert is installed or an old insert is reconditioned, the work must be done with a grinding tool.

(5) The eccentric grinding method for reconditioning valve seat inserts is recommended. This method produces a finer, more accurate finish since only one point of the grinding wheel is in contact with the valve seat at any time. A micrometer feed permits feeding the grinding wheel into the work .001 inch at a time.

(6) The eccentric valve seat grinder set, tool J 8165, used to recondition or grind the valve seat inserts consists of:

(a) Grinder, tool J 8165-1.

(b) Dial gage, tool J 8165-2.

(c) Pilot, tool J 8165-3.

(d) Grinding wheel (15°), tool J 8165-4.

(e) Grinding wheel (30°), tool J 8165-5.

(f) Grinding wheel (60°), tool J 8165-7.

(7) Grind the inserts as follows:

(a) Use the 30° grinding wheel on the valve seat.

(b) Use the 60° grinding wheel to open the throat of the insert.

(c) Grind the top surface of the insert with the 15° wheel to narrow the width of the seat to the dimensions shown in figure 3-56. Adjust the 30° face of the insert, relative to the center of the valve face, with the 15° and 60° grinding wheels.

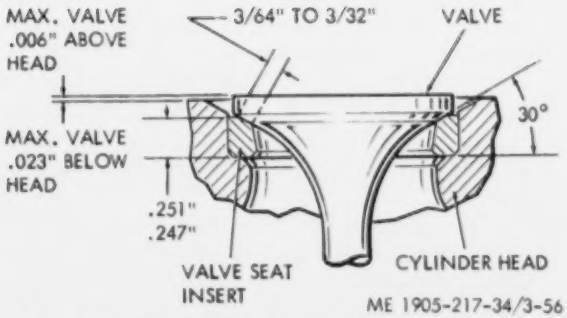


Figure 3-56. Relationship between exhaust valve, insert, and cylinder head.

CAUTION

Do not permit the grinding wheel to contact the cylinder head when grinding the insert.

(8) The maximum allowable limits the exhaust valve should protrude beyond the cylinder head (when the valve is closed) for the valve seat inserts is shown in figure 3-56. Grinding will reduce the thickness of the valve seat insert, which will allow the valve to recede into the head. These maximum allowable limits are also shown and if the grinding operations reduce the valve seat thickness so that the valve recedes beyond these limits, the valve seat insert must be replaced.

(9) After the grinding has been completed, clean the valve seat insert thoroughly with fuel oil and blow it dry with compressed air. Set the dial indicator J 8165-2 in position and rotate it to determine the concentricity of each valve seat insert relative to the valve guide. Total runout should not exceed .002 inch. If a runout of more than .002 inch is indicated, check for a bent valve guide before regrinding the insert.

(10) When a valve seat insert runout within the desired limits is obtained, determine the position of the contact area between the valve and the valve seat insert in the following manner:

(a) Apply a light coat of Prussian blue, or a similar paste, to the valve seat insert.

(b) Lower the stem of the valve in the valve guide and bounce, but do not rotate the valve on the insert. This procedure will indicate the area of contact on the valve face. The most desirable area of contact is at the center of the valve face.

(11) Dress the grinding wheel to obtain the proper seat angle. After the valve seat inserts have been ground and inspected, clean the cylinder head thoroughly before installing the valves.

d. Reassembly and Installation.

(1) *Exhaust Valve Guide.* Turn the cylinder head right side up on the work bench and install the valve guide as follows:

(a) Insert the internally threaded end of the valve guide in the J 9530 valve guide installing tool.

CAUTION

Be sure to use the correct tool to avoid damage to the valve guide, and to locate the valve guide to the proper dimension above top of head.

(b) Position the valve guide squarely in the bore in the cylinder head and tap the installing tool gently to start the guide in place. Then, drive the guide in until the tool contacts the cylinder head.

NOTE

Do not use the valve guides as a means of turning the cylinder head over or in handling the cylinder head.

NOTE

Service replacement valve guides are completely finish reamed during manufacture and, therefore, do not require reaming after installation.

(2) *Exhaust Valve Seat Insert.* Great care must be used during the installation of a valve seat insert since this part has a press fit in the cylinder head. Install the insert in the following manner:

(a) Wash the cylinder head with fuel oil and dry it with compressed air.

(b) Clean the valve insert counterbore in

he cylinder head with trichloroethylene or other ood solvent. Also, wash the valve inserts with he same solvent. Dry both the counterbores and he inserts with compressed air.

(c) Inspect the valve seat insert counerbores in the cylinder head for cleanliness, oncentricity, flatness and cracks. The counerbores in the cylinder heads have a diameter of .626 inch to 1.627 inch and a depth of .3705 inch o .3845 inch. If required, use valve seat inserts hich are .010 inch oversize on the outside iameter.

(d) Immerse the cylinder head for at least 0 minutes in water heated to a temperature of 85° F. to 200° F.

(e) Rest the cylinder head, bottom side up n a work bench and locate the insert squarely in he counterbore, seating face up. Install the insert n the cylinder head while the head is still hot and he insert is at room temperature, otherwise nstallation will be difficult and the parts may be amaged.

(f) Drive the inserts in place with installer 1736, until they seat solidly in the cylinder ead.

(g) Grind the valve seat inserts and check hem for concentricity in relation to the valve uides as outlined below.

(3) *Exhaust Valves and Springs.* After the alve guides have been checked or replaced, the alves and valves seat inserts replaced or econditioned, install the exhaust valves as ollows:

(a) Clean the valve guides.

(b) Lubricate the valve stems and slide the alves all the way into the guides.

NOTE

If reconditioned valves are used, install them in the same relative location from which they were removed.

(c) Hold the valves in place with a strip of masking tape and turn the cylinder head right side up on the work bench. Place a board under the head to support the valves and to provide clearance between the cam followers and the bench.

(d) Install the valve spring seats.

(e) Install the valve springs, and valve spring caps.

(f) Thread the valve spring compressor J 7455 into one of the rocker shaft bolt holes in the cylinder head.

(g) Apply pressure to the free end of the tool to compress the valve spring and install the two-piece tapered valve lock. Exercise care to avoid scoring the valve stem with the valve cap when compressing the spring.

CAUTION

Compress the valve spring only enough to permit installation of the valve locks. Compressing the spring too far may result in damage to the valve guide oil seal if used.

(h) Release the tool and install the valve locks on the remaining exhaust valves in the same manner.

NOTE

After the valves have been installed, make sure that none of the valve heads protrude more than the limits shown in figure 3-56 above the surface of the cylinder head when the valves are fully closed.

3-16. Idler Gear Assembly and Hole Spacer

a. General.

(1) The idler gear (fig. 3-58) mounts on a double row, tapered roller bearing which, in turn, is supported on a stationary hub. A hollow pin serves a two-fold purpose; first, as a locating dowel it prevents the idler gear hub from rotating and, second, the hollow pin conducts oil under pressure from an oil gallery in the cylinder block through a passage in the gear hub to the roller bearing inner races.

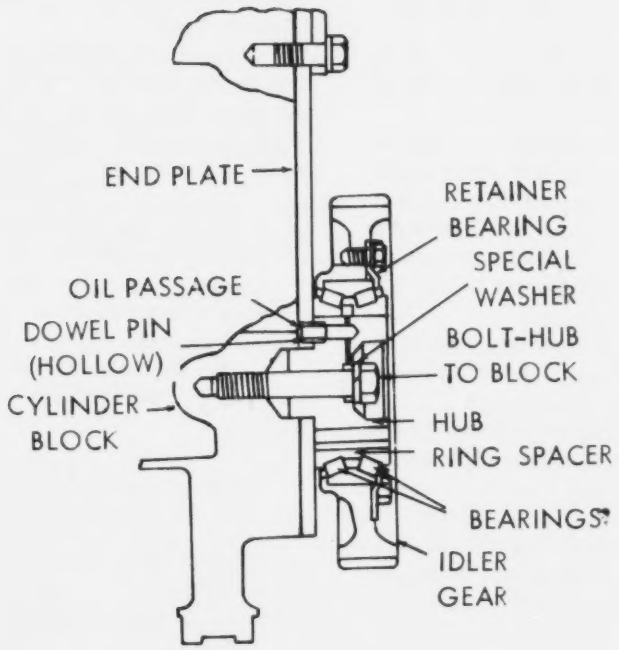


Figure 3-57. Idler gear assembly, cross section view.

(2) The inner races of the idler gear bearing are pressed onto the gear hub and, therefore, do not rotate since the hub is doweled to the end plate and bolted to the cylinder block and also bolted to the flywheel housing. A spacer, on current bearings, separates the two bearing inner races. No spacer was used on early design bearings.

(3) The bearing outer race has a light press fit in the idler gear and is held against a flanged lip inside the idler gear on one side and by a retainer secured tightly with six bolts on the other side.

(4) A right-hand helix gear with "L" timing marks is provided for left-hand rotation engines, and a left-hand helix gear with "R" timing marks is provided for right-hand rotation engines.

(5) An idler gear hole spacer (dummy hub) is used on the side opposite the idler gear. NO gasket is used between the idler gear hub or dummy hub and the flywheel housing. The flywheel housing bears against the inner races of the idler gear bearing and also against the dummy hub. Three self-locking bolts and steel washers are used to attach the flywheel housing at the idler gear and dummy hub locations. The washers seat in 7/8" spot faces at the flywheel housing attaching bolt holes, thus preventing oil leakage at these locations.

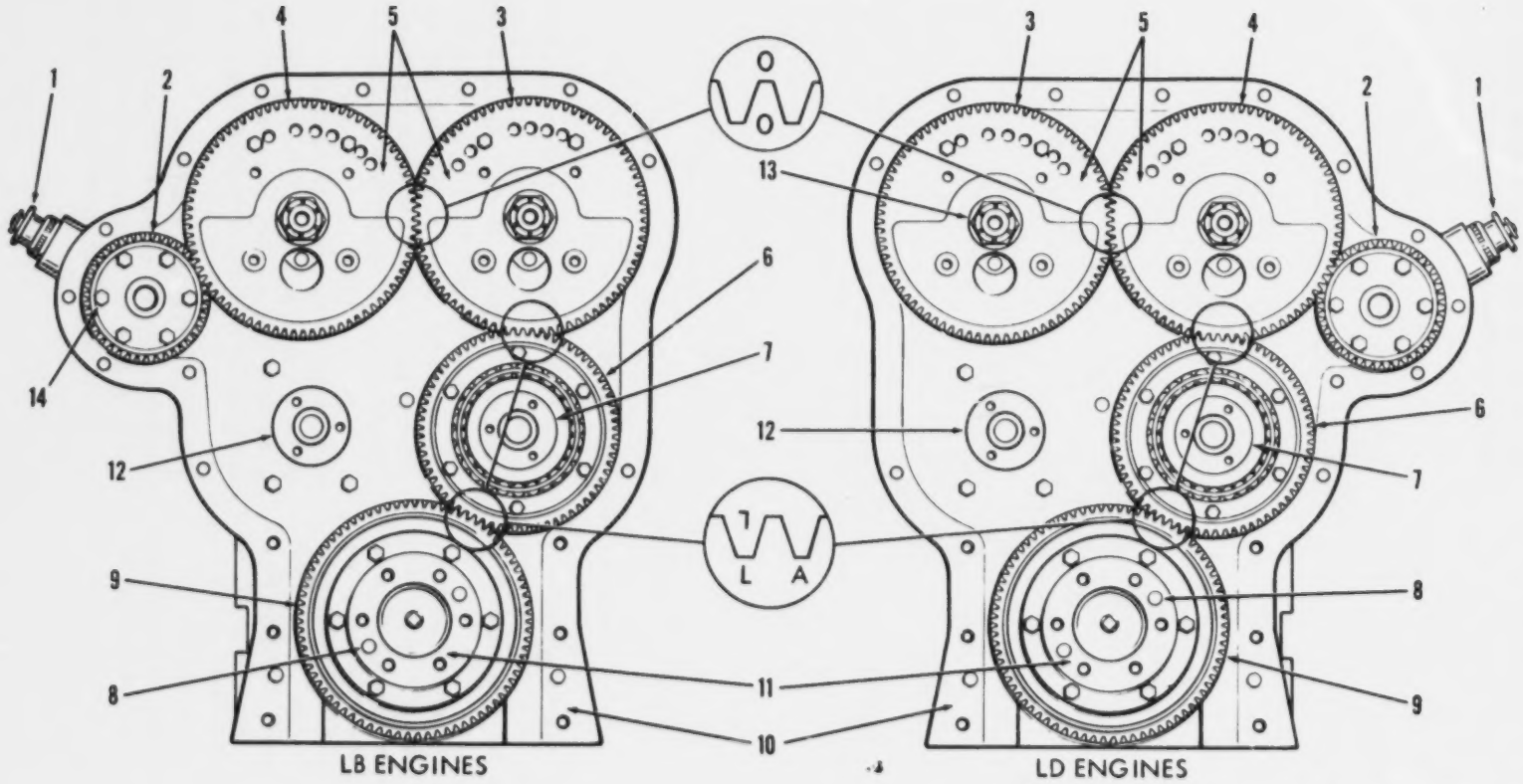
b. Removal. (Flywheel Housing Removed).

(1) Remove the hub to cylinder block bolt and washer (Figure 3-57) and withdraw the assembly from the cylinder block rear end plate.

NOTE

Before removing the idler gear check the idler gear, hub and bearing assembly for any perceptible wobble or shake when pressure is applied; by firmly grasping the rim of the gear with both hands and rocking it relation to the bearing. The bearing must be replaced if the gear wobbles or shakes. If the gear assembly is satisfactory, it is only necessary to check the pre-load before reinstallation.

(2) Remove the idler gear hole spacer (12, fig. 3-58), in the same manner if the engine is being completely reconditioned.



1. Oil filler cap
2. Blower drive gear
3. Camshaft gear
4. Balance shaft gear
5. Rear balance weight
6. Idler gear
7. Idler gear hub
8. Crankshaft dowel
9. Crankshaft gear
10. Cylinder block end plate (rear)
11. Crankshaft
12. Spacer, idler gear hole
13. Gear retaining nut
14. Driving coupling bolt

Figure 3-58. Idler gear hole spacer, removal and installation.

(3) While removing or installing an idler gear bearing, the bearing MUST be rotated to avoid the possibility of damaging the bearing by brinelling the bearing races. Brinelling refers to the marking of races by applying a heavy load through the rollers of a non-rotating bearing in such a way that the rollers leave impressions on the contact surfaces of the races. These impressions may not be easily discerned during normal inspection. For example, a bearing may be brinelled if a load were applied to the inner race of the bearing assembly in order to force the outer race into the idler gear bore, thus transmitting the force through the bearing rollers. A brinelled bearing may have a very short life.

c. Disassembly. Refer to figure 3-59 for the location and identification of parts and disassemble the bearing as follows:

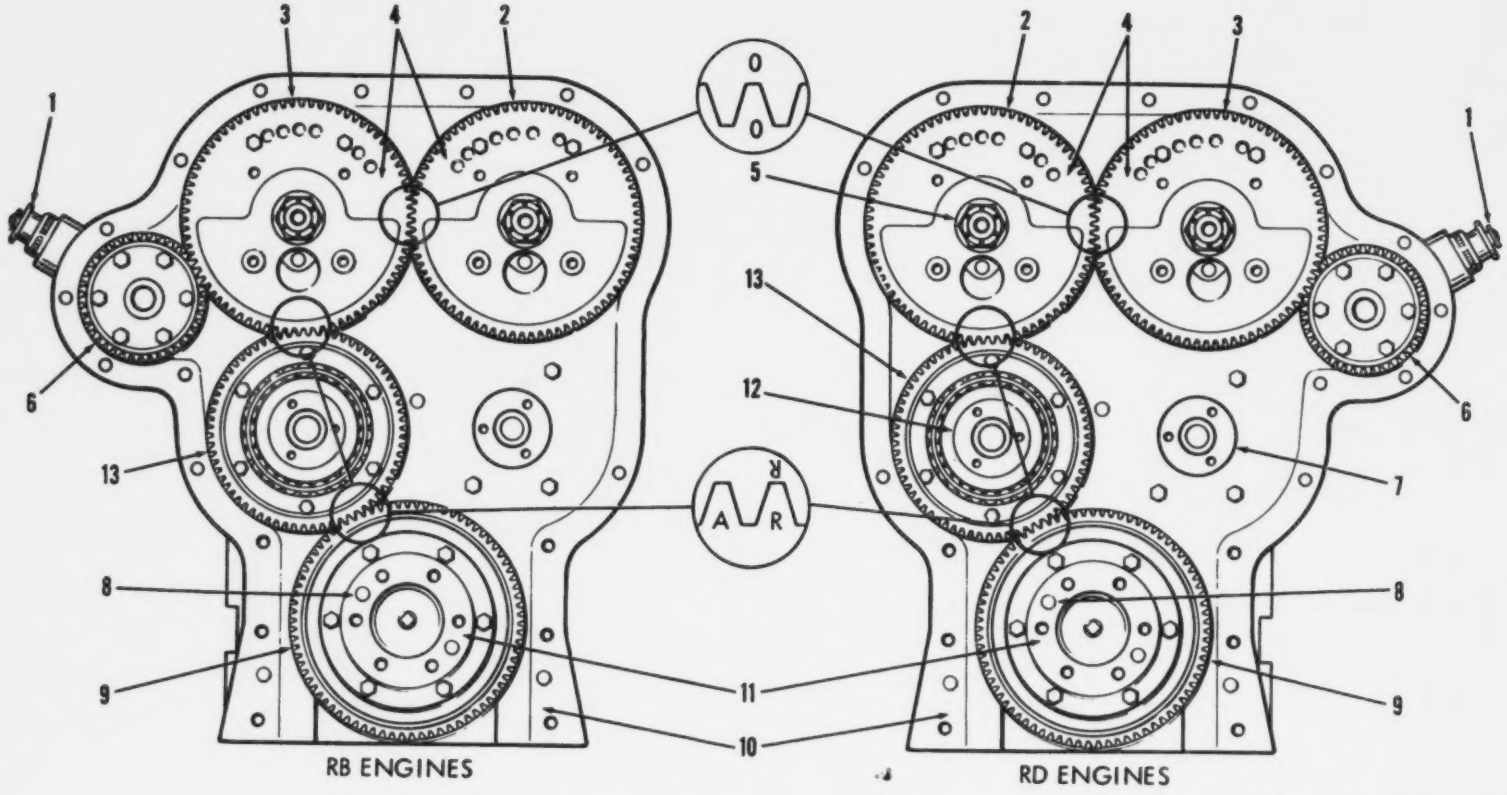


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Figure 3-59. Idler gear assembly, disassembly and reassembly.

(1) Remove the six bolts and three bolt locks which secure the bearing retainer to the idler gear.

(2) Place the idler gear and bearing assembly in an arbor press with the bearing cone or inner race supported on steel blocks as shown in figure 3-60. While rotating the gear assembly, press the hub out of the bearing. Remove the gear assembly from the arbor press and remove the bearing cones and spacer. (fig. 3-61).

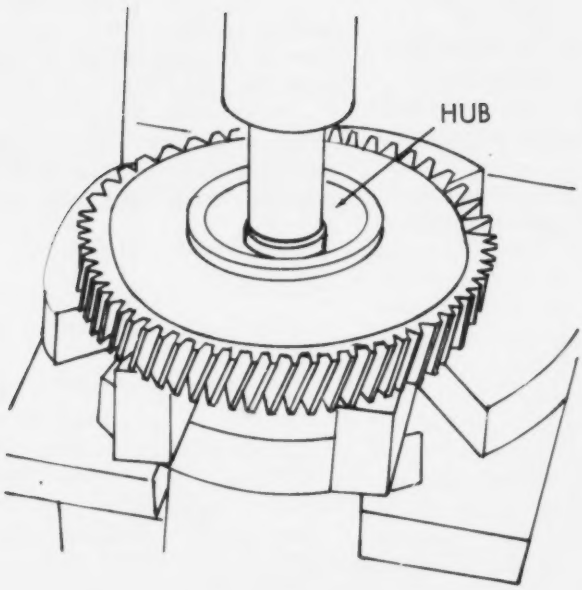

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Figure 3-60. Pressing hub out of bearing.

NOTE

Component parts of the idler gear bearing are mated; therefore, match-mark the parts during disassembly to assure they will be reassembled in their original positions.

(3) Tap the bearing cup (outer race) from the idler gear by using a brass drift alternately at four notches provided around the shoulder of the gear.

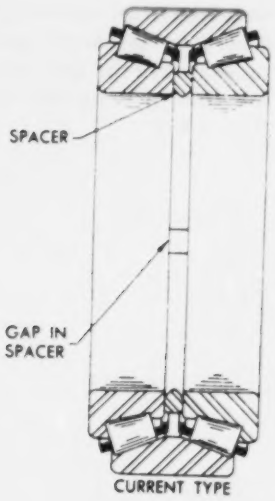

Figure 3-61. Idler gear bearing and spacer, cross-section view.

(a) After pressing out the idler gear hub, (fig. 3-59), place the gear assembly on a clean work surface with the rear face of the gear toward the work surface.

(b) Position the inner races until the notches in the bearing cones are approximately 180° from the gap of the spacer.

(c) Press against the spacer and gently rock the gear to release the spacer from the grooves in the bearing cones. The tang of a small file, or a similar tool, may be used for this operation. Ordinarily, the spacer will remain with one of the two bearing cones.

CAUTION

Exercise care to prevent the rollers escaping their cage and scattering. If this should occur, the bearing SHOULD NOT be reassembled and reused since the rollers were selectively mated to the bearing races when originally manufactured. A new bearing assembly must be used.

(d) Lift the gear, bearing outer race, top inner race and its rollers away from the bottom inner race and the rollers.

(e) Hold the top inner race and the rollers against the outer race, turn the gear over, and place it on work surface. Then lift the gear away from the inner race and the rollers.

(f) Make a hardwood ram as shown in figure 3-62. Then position the idler gear in the arbor press and with the gear suitably supported, press the outer race from the gear.

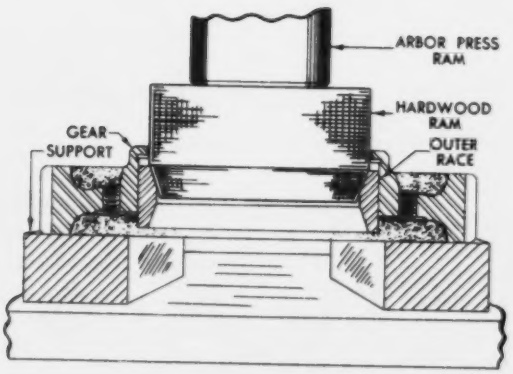

Figure 3-62. Hardwood ram for pressing outer race from gear.

(g) Four equally spaced notches, approximately 3/16" radius, may be filed or ground the shoulder of the gear as shown in figure 3-. Use care to avoid damage to the bore in the ar, break all sharp edges, and clean all chips d dirt from the gear.

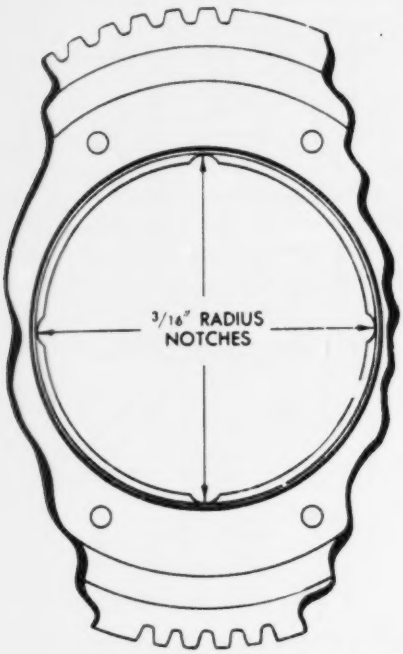

Figure 3-63. Location of notches in idler gear.

d. Cleaning and Inspection.

(1) Clean the idler gear, hub, and bearing omponents in cleaning solvent (FED. SPEC. D-680) and dry with compressed air.

(2) Inspect bearings carefully. Wear, pitting, scoring or flat spots on rollers or races are ufficient cause for rejection and the bearing ssembly must be replaced.

(3) Check the idler gear hub and spacer. The hree flywheel housing mounting bolt holes were ot drilled through on early design hubs and pacers. Consequently, these hubs must be inpected to assure that no chips or foreign material deposited in the holes so as to cause interference with the flywheel attaching bolts.

(4) Examine the gear teeth for evidence of coring, pitting and wear. If severly damaged or orn, replace the gear. Also, inspect other gears n the gear trains.

e. Reassembly. Refer to figure 3-59 and ssemble bearing components in their original ositions (refer to identification marks made uring disassembly) as outlined below:

(1) Support the idler gear, shoulder down, on the bed of an arbor press and start the outer bearing race squarely into the bore of the gear. Then, press the bearing race tight against the shoulder of the gear, using a steel plate between the ram of the press and the bearing race.

(2) Support one bearing cone, numbered side down, on bed of arbor press and lower the idler gear and bearing cup assembly down over the bearing cone.

(3) Lay spacer ring on face of bearing cone.

(4) Place second bearing cone, numbered side up, in idler gear and bearing cup assembly and against spacer ring.

(5) Then, position the idler gear hub over the bearing cones so that the oil hole in the hub is 180° from the gap in the spacer ring. To assemble the early design bearing in which the bearing cones are held together by a snap ring, use the following procedure:

(a) Place first bearing cone on work bench and place idler gear shoulder face up, over cone.

(b) Lift both idler gear and bearing cone together, *being careful that the rollers do not escape their retainer,* and invert the gear and cone and place them over the second cone.

(c) Press the upper bearing cone down by hand, then rock it to engage the snap ring in the grooves of the cones. *Do not lift the gear and bearing assembly from the work bench until the snap ring is engaged.*

(d) Position notches of bearing cones so they are together.

(e) Then, position the idler gear hub over the bearing cones so the oil hole in the hub is 180° from the notches in the cones.

(6) Press the hub into the idller gear bearing cones, while rotating the gear (to seat rollers properly between cones) until the face of the hub which will be adjacent to the cylinder block end plate is flush with the corresponding face of the bearing cone. The bearing cones should be supported so as not to load the bearing rollers during this operation.

(7) Prior to installing and securing the bearing retainer, check the preload of the bearing assembly as outlined below.

f. Checking Bearing Preload.

(1) The rollers of the bearing are loaded between the bearing cup and bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and cup. In the idler gear bearings, a slight pre-load is applied by means of a selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub.

This method of pre-loading is measured, in terms of "pounds-pull", by the effort required at the outer diameter of the gear to turn the bearing cup in relation to the bearing cones.

(2) Any time an idler gear assembly has been removed from an engine for servicing or inspection, while performing engine overhaul or other repairs, the pre-load should be measured as part of the operation.

(3) After the idler gear, hub, and bearing are assembled together, the bearing should be checked to ascertain that the gear may be rotated on its bearing without exceeding the maximum torque specifications, nor be so loose as to permit the gear to be moved in relation to the hub by tilting, wobbling or shaking the gear.

(4) If the mating crankshaft and camshaft or balance shaft gears (depending upon engine rotation) are not already mounted on the engine, the torque required to rotate the idler gear may be checked by mounting the idler gear in position on the engine, using a steel plate 4" square and 3/8" thick against the hub and cone as outlined below.

(5) However, if the crankshaft and camshaft gears are on the engine, a suitable fixture, which may be held in a vise, may be made as shown in figure 3-64. Three plates, a 1/2"-13 x 2 3/4" bolt and a plain washer are used with a ½"-13 nut and plain washer for mounting. One of the plates is used to take the place of the flywheel housing, and the other two plates, the cylinder block. "Engine-mounted" conditions are simulated by tightening the nut to 80-90 lb-ft torque and tightening the three plate-to-hub attaching bolts to 25-40 lb-ft torque. The components of the fixture may be made from steel stock in accordance with the dimensions shown in figure 3-65.

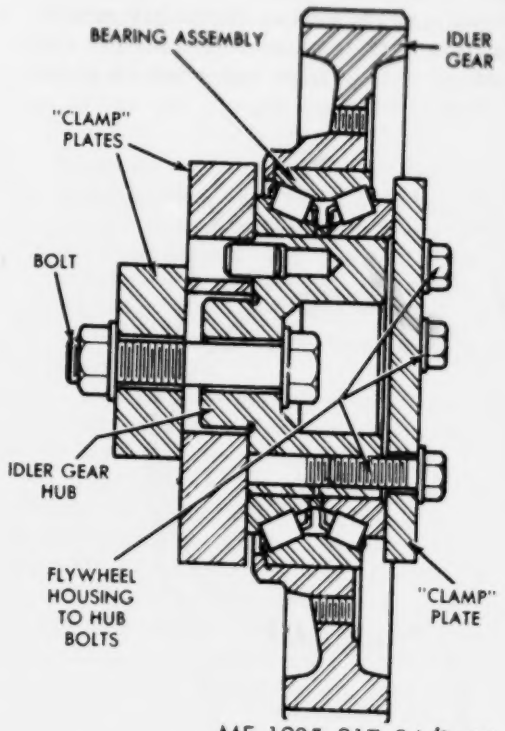

Figure 3-64. Fixture for testing bearing pre-load.

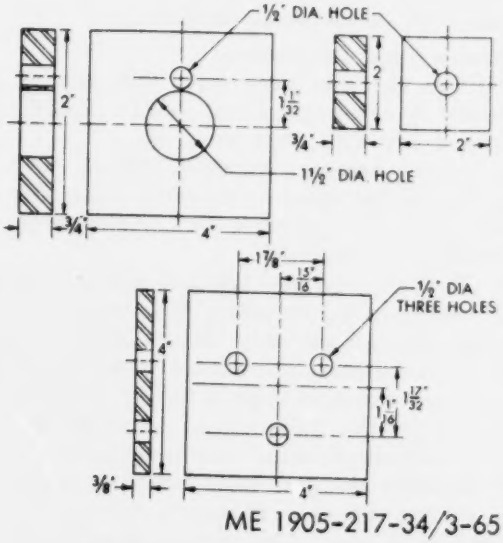

Figure 3-65. Plates for bearing test fixture.

(6) The idler gear bearing should be clean l lubricated with clean light engine oil prior to pre-load test. Idler gear assemblies which lude new bearings should be "worked in" by sping the gear firmly by hand and rotating the r back and forth several times.

(7) To check the pre-load by the first thod:

(a) Mount the idler gear assembly on the gine.

(b) Install the center bolt and washer ough the gear hub and thread into the cylinder ck (effective with 3A-48440, 4A-96718, 6A-509 a ½"-13 x 2 ½" bolt replaced the ½"-13 x bolt). Tighten the bolt to 80-90 lb-ft torque.

(c) Place steel plate (lower plate shown in ure 3-65) against hub and bearing. Insert three 3/8"-16 bolts through plate and thread into hub. Tighten the bolts to 25-40 lb-ft torque.

(d) Tie one end of a piece of lintless 1/8" cord around a 1/8" round piece of wood (or soft metal stock). Place the wood between the teeth of gear, then wrap the cord around the periphery of the gear several times. Attach the other end of the cord to spring scale, J 8129 (fig. 3-66). Maintain a straight, steady pull on the scale, 90° to the axis of the hub, and note the pull, in pounds and ounces, required to start the gear rotating. Make several checks to obtain an average reading. If the pull is within ½ lb. minimum to 6 lbs. 12 ounces maximum and does not fluctuate more than 2 lbs. 11 ounces, the idler gear and bearing assembly are satisfactory for use.

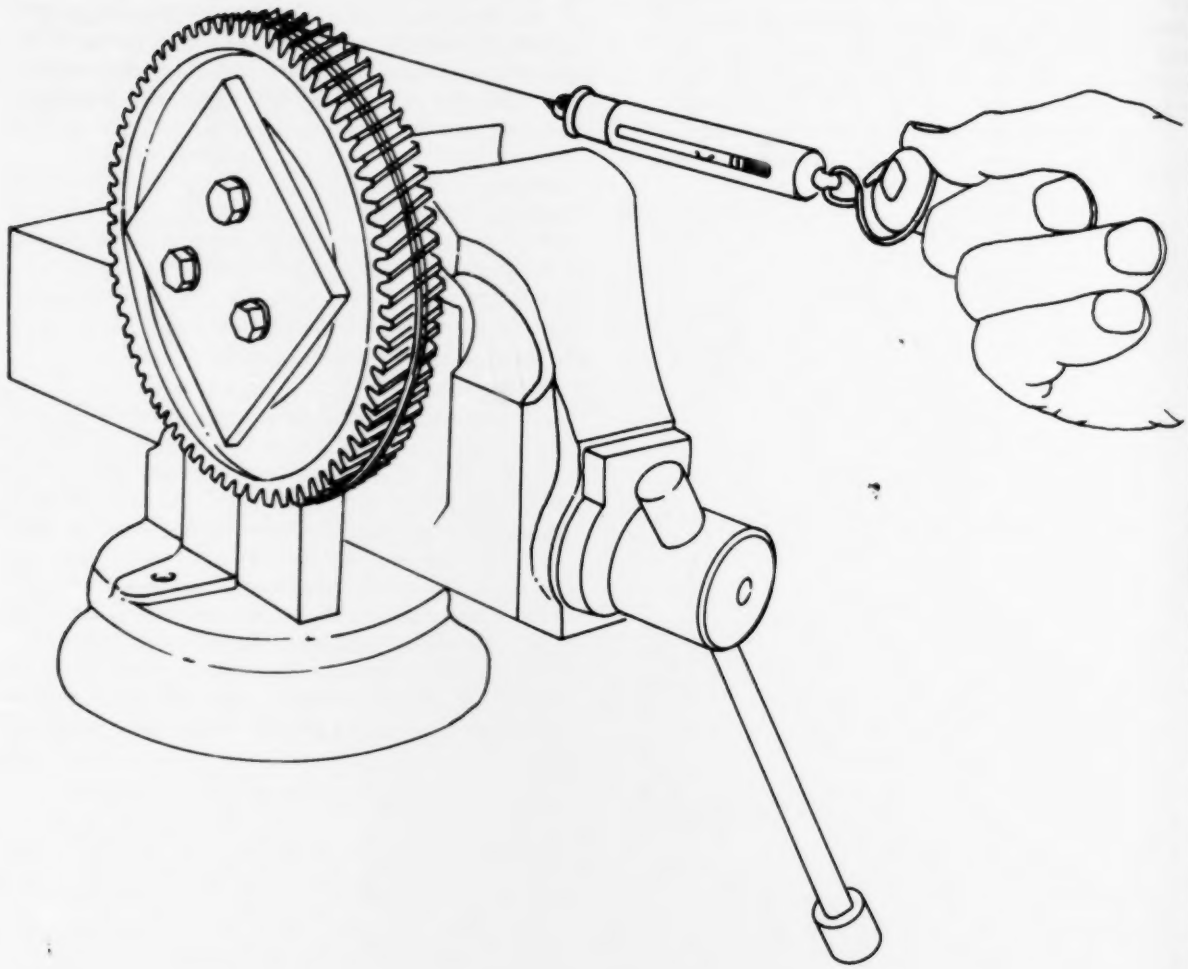

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Figure 3-66. Checking pre-load of idler gear bearing.

NOTE

The specified pull is 1½ to 15 lbs. for the early design bearing assembly which incorporates the snap ring.

(8) To check the pre-load by the second method:

(a) Attach the plates (two upper plates of fig. 3-65) to the idler gear with ½"-13 center bolt, washers and nut as shown in figure 3-64. Tighten the bolt to 80-90 lb-ft torque.

(b) Attach the other plate to the idler gear with three 3/8"-16 bolts. Tighten the bolts to 25-40 lb-ft torque.

(c) Clamp the idler gear assembly and ure in vise as shown in figure 3-66.

(d) Attach the cord to the idler gear and ing scale and check the pre-load as outlined in n (d) of the first method.

(9) If the scale reading is within the specified to 6-3/4 lbs., but fluctuates more than the missible 2 lbs. 11 ounces, the idler gear and ring assembly must NOT be installed on the ine. Fluctuations in scale reading may be sed by the races not being concentric to each er, damaged races or rollers, or dirt or foreign terial within the bearings. In these cases, the ring should be inspected for the cause of tuation in the scale readings and corrected or ew bearing installed.

(10) A scale reading which exceeds the cified maximum indicates binding of the ring rollers, or rollers improperly installed. e bearing should be disassembled, inspected l replaced, if necessary.

(11) If the scale reading is less than the cified minimum, the bearing is more likely rn. However, the assembly may be installed on engine, PROVIDED the gear has no per- tible wobble or shake.

(12) After the pre-load test is completed, ove the steel plates and attach bearing ainer as follows:

(a) Attach the bearing retainer to the idler r with six bolts and three bolt locks. Tighten bolts 10 24-29 lb-ft torque.

(b) Bend the ears of each bolt lock against flat side of the attaching bolt heads to secure bolts.

NOTE

Idler gear assemblies which have a total length of 1.514" to 1.519" are to be used ONLY on engines equipped with a cast iron flywheel housing. Idler gear assemblies with a total length of 1.509" to 1.514" are used on engines with an aluminum flywheel housing and may also be used with cast iron housings.

g. *Installation.*

(1) Position the crankshaft gear and either balance shaft or camshaft gear (depending on engine rotation) so that the match marks l align with those on the idler gear.

(2) With these marks in alignment, start the er gear into mesh with the crankshaft gear and her the camshaft or balance shaft gear, and ultaneously rotate the gear hub so that the llow pin at the inner face of the hub nearly isters with the oil hole in the end plate.

(3) Roll the idler gear into position, align the llow pin with the hole in the end plate, and ntly tap the hub until it seals against the end te. Thus the hollow dowel pin in the hub will conduct oil through the end plate and into the hub where it flows through a drilled passage to the roller bearing.

(4) After making sure that the hub is tight against the end plate, secure the idler gear assembly in place with a ½"-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft torque (cast iron cylinder block) or 50-55 lb-ft torque (aluminum cylinder block).

(5) If previously removed, install the idler gear hole spacer (dummy hub). Secure the spacer to the cylinder block end plate and cylinder block with a ½"-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft torque (cast iron cylinder block) or 50-55 lb-ft torque (aluminum cylinder block).

NOTE

Current engines use a new idler gear hub and idler gear hole spacer (dummy hub) which required ½"-13 x 2½" retaining bolts, replacing the ½"-13 x 2" bolts formerly used.

(6) Lubricate the idler gear and bearing liberally with clean engine oil.

(7) Check the backlash between the mating gears. The backlash must be .003" to .008".

(8) No gasket is used between the roller bearing type idler gear assembly and the flywheel housing. However, if an OLD design idler gear spacer is used (on early engines), a small flywheel housing gasket must be used between the spacer and the flywheel housing.

NOTE

Make sure the oil passage in the cylinder block is plugged at the dummy hub location.

(9) If the roller bearing type idler gear assembly has been installed in place of a copper-lead flange type bearing on an early engine, it will be necessary to rework the flywheel housing at the idler gear hub pads to provide the 7/8" spot faces at the bolt holes.

(10) Install the flywheel housing.

3-17. Gear Train and Engine Timing

a. General.

(1) A completely enclosed train of five helical gears is located at the rear end of the engine. A gear bolted to the crankshaft flange drives the camshaft and balance shaft gears, as well as the blower drive gear, through an idler gear mounted between the crankshaft and balance shaft gears on the RB and LD engines, and between the crankshaft and camshaft gears on the RD and LB engines. Refer to TM 55-1905-217-12 (para 4-19b).

(2) The camshaft gear and balance shaft gear mesh with each other and run at the same speed as the crankshaft. Since these two gears must be in time with each other, and the two as a unit in

time with the crankshaft gear, the letter "O" is placed on one tooth of one of the gears with a corresponding mark at the root of the mating teeth of the other gear.

(3) The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. Viewing the engine from the flywheel or gear train end, the righthand gear, whether on the balance shaft, as shown on RD and LD engines, or the camshaft, as shown on RB and LB engines, has left-hand helical teeth.

(4) The idler gear rotates on a double-row, tapered roller bearing mounted on a stationary hollow hub. This hub is accurately located on the cylinder block end plate, at the right-hand side of the LB and LD engines and at the left-hand side of the RB and RD engines, as viewed from the gear train end.

(5) A blower drive gear is located on the blower side to transmit power to the blower, governor, fuel pump and water pump.

(6) Since, as stated above, the cam and balance shafts must be in time with the crankshaft, identification marks are located on two teeth of the idler gear with corresponding match marks stamped on the crankshaft gear and the camshaft or balance shaft gear.

(7) Gear train noise is usually an indication of excessive gear lash, scoring, pitting or excessive bearing wear. Therefore, when noise develops in a gear train, the flywheel housing should be removed and the gear train and its bearings inspected. A rattling noise usually indicates excessive gear lash whereas a whining noise is a result of too little gear lash.

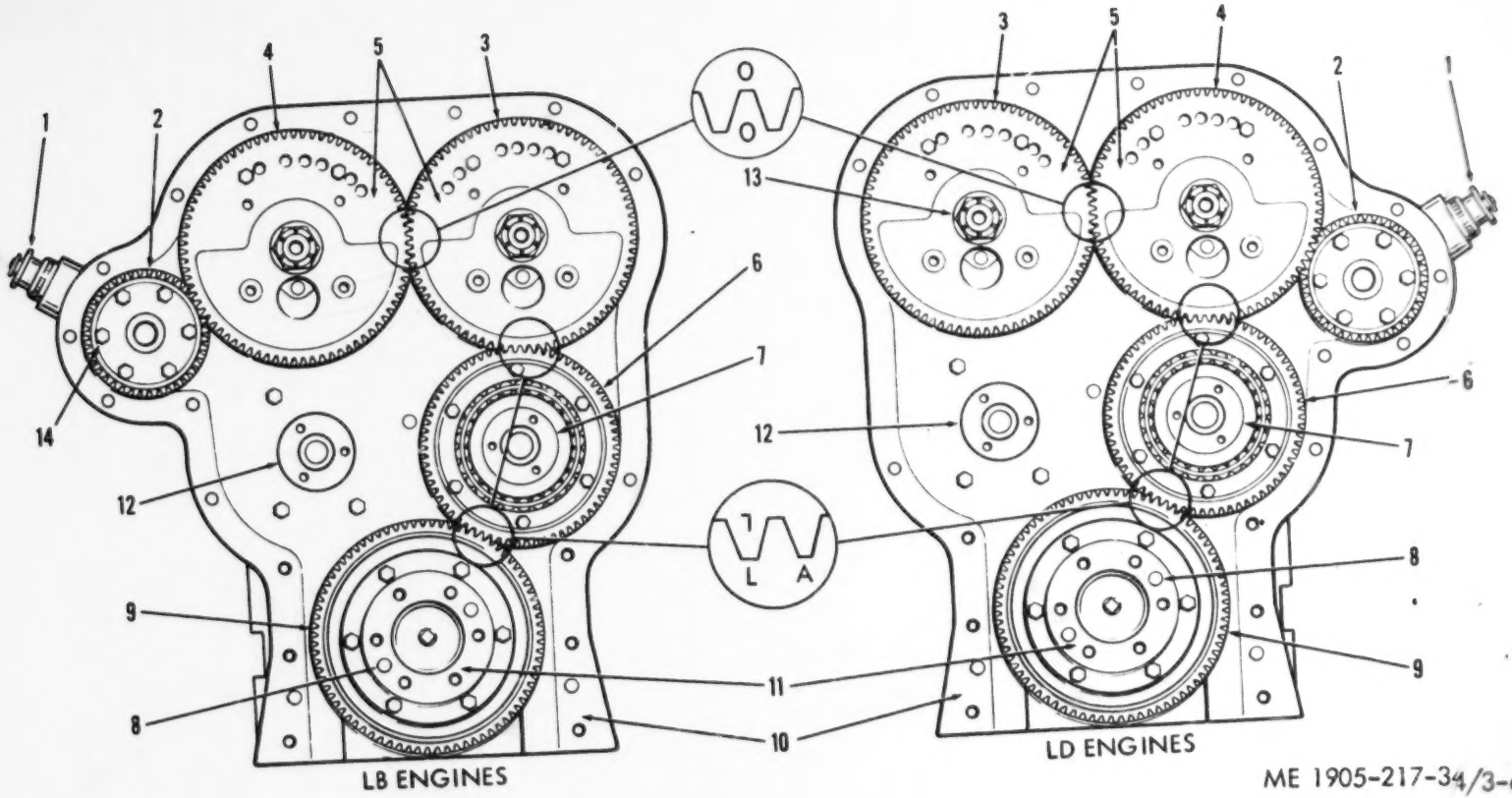
(8) Excessive wear and scoring may result from abrasive substances or foreign material in the oil, introduced in the engine by such means as removal of the rocker cover without first cleaning away the dirt.

(9) The backlash between the various mating gears in the current 19° helix steel gear train ranges from .003 inch to .008 inch with new parts.

b. Engine Timing.

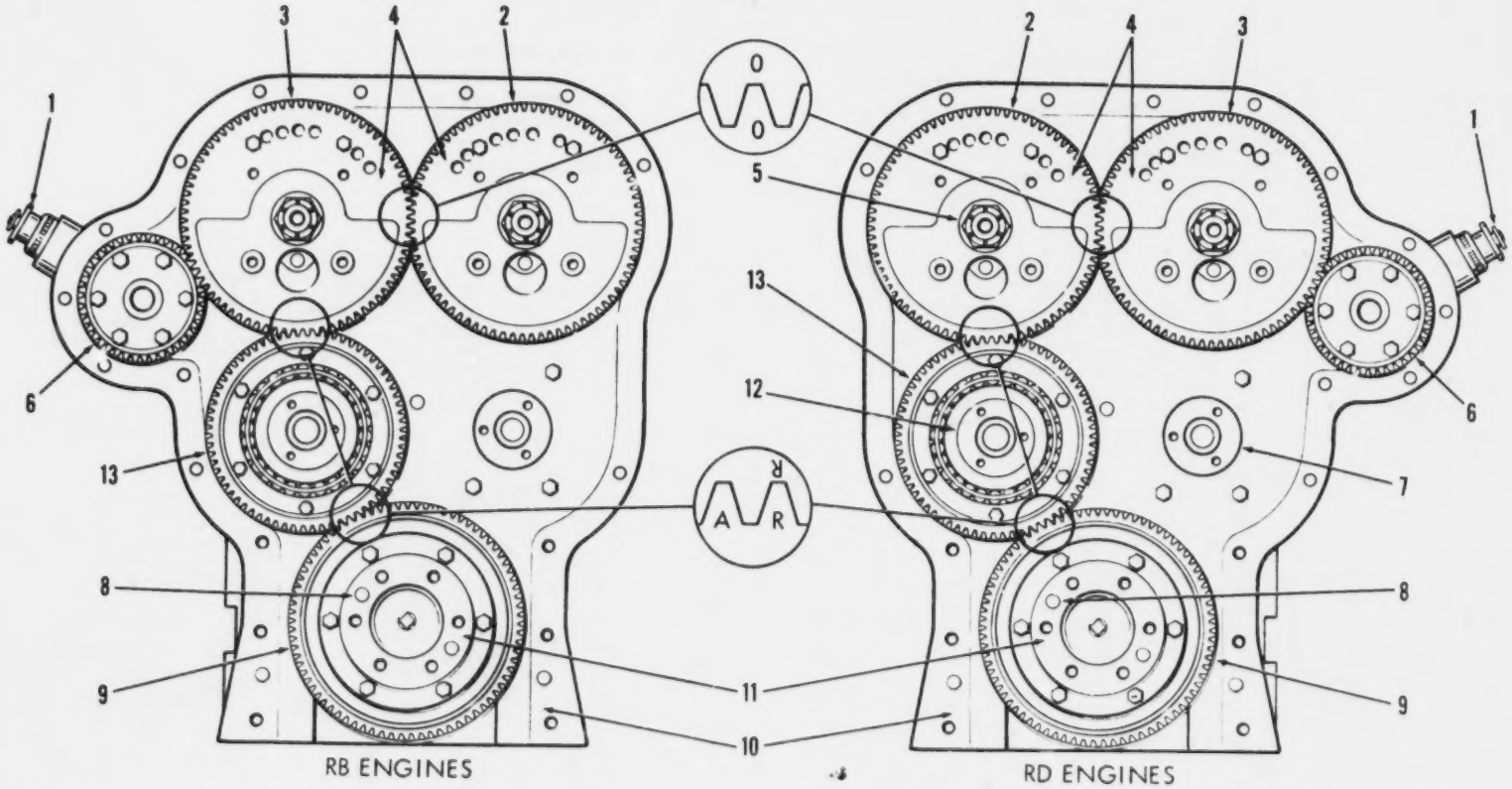
(1) The correct relationship between the crankshaft and camshaft must be maintained to properly control fuel injection and the opening and closing of the exhaust valves.

(2) The crankshaft timing gear can be mounted in only one position due to one attaching bolt hole being offset The camshaft gear can also be mounted in only one position as a result of the location of the keyway relative to the cams. Therefore, when the engine is properly timed, the markings on the various gears will match as shown in figures 3-67 and 3-68.



1. Oil filler cap
2. Blower drive gear
3. Camshaft gear
4. Balance shaft gear
5. Rear balance weight
6. Idler gear
7. Idler gear hub
8. Crankshaft dowel
9. Crankshaft gear
10. Cylinder block end plate (rear)
11. Crankshaft
12. Spacer, idler gear hole
13. Gear retaining nut
14. Driving coupling nut

Figure 3-67. Gear train and timing marks—left-hand rotation engines.



1. Oil filler cap
2. Camshaft gear
3. Balance shaft gear
4. Rear balance weight
5. Gear retaining nut
6. Blower drive gear
7. Idler gear hole spacer
8. Crankshaft dowel
9. Crankshaft gear
10. Cylinder block end plate (rear)
11. Crankshaft
12. Idler gear hub
13. Idler gear

Figure 3-68. Gear train and timing marks—right-hand rotation engines.

(3) An engine which is "out of time" may esult in pre-ignition, uneven running and a loss f power.

(4) When an engine is suspected of being out f time, due to an improperly assembled gear rain, a quick check can be made without having o remove the flywheel and flywheel housing by ollowing the procedure outlined below.

c. *Checking Engine Timing.* Access to the ibration damper or crankshaft pulley, to mark he top-dead-center position of the selected iston, and to the front end of the crankshaft or lywheel for barring the engine over is necessary n performing the timing check. Then, proceed as ollows:

(1) Remove the cylinder head rocker cover.

(2) Select any cylinder for the timing check. t is suggested that a cylinder adjacent to one of he cylinder head cover studs be chosen since the tud may be used for mounting a dial indicator.

(3) Remove the fuel lines (at the cylinder elected) and install shipping caps on injector fuel ttings to prevent the entry of dirt. Make sure hat the valve and injector rocker arms are all in he "up" position, then remove the rocker shaft racket bolts and swing the rocker arm assemlies back out of the way. Remove the injector ssembly.

(4) Carefully place (do not drop) a rod approximately 12 inches long through the injector ole and on top of the piston. With the throttle in he NO FUEL position, turn the crankshaft owly in the direction of rotation of the engine, nd stop when the rod reaches the end of its pward travel. Remove the rod and turn the rankshaft opposite the direction of rotation etween 1/16 and 1/8 of a turn.

(5) Select a dial indicator with .001 inch raduations and with a spindle movement of at ast 1 inch. Use suitable mounting attachments or the indicator so that it can be mounted over he injector hole in the cylinder head. Provide an xtension for the spindle of the indicator. The xtension must be long enough to contact the iston as it approaches its upper position.

(6) Mount the indicator over the injector ole and tighten mountings sufficiently to hold he indicator rigid. The mounting leg may be hreaded into the rocker cover stud; or, the stud ay be removed from the cylinder head and the g threaded into the tapped hole, depending upon he length of the rod used in making up the ounting attachments. Make sure that the indle extension is free in the injector hole, does ot bind, and is free to travel its full 1 inch ovement.

(7) Provide a suitable pointer and attach it the crankshaft front cover or engine front end plate. The pointer should extend over the vibration damper, or crankshaft pulley, whichever is used.

(8) Rotate the crankshaft in the direction of rotation slowly until the hand on the dial indicator just stops moving.

(9) Rotate the crankshaft in the direction of rotation until the indicator hand just starts to move. Reset dial to "O". Continue turning the crankshaft slowly until the indicator reading is .010 inch—then stop turning.

(10) Scribe a line on the damper (or crankshaft pulley) in line with the end of the pointer.

(11) Rotate the crankshaft opposite the direction of rotation slowly until the hand on the dial indicator just stops moving.

(12) Rotate the crankshaft opposite the direction of rotation until the indicator hand just starts to move. Reset dial to "O". Continue turning the crankshaft slowly until indicator reading is .010 inch—then stop turning.

(13) Scribe a second line on the vibration damper (or crankshaft pulley) in the same manner as in step 10.

(14) Scribe a third line halfway between the first two lines. This is positive top-dead-center. Remove the indicator from the engine.

NOTE

Make certain that the crankshaft pulley retaining bolt is not loosened while turning the crankshaft. The bolt must be tightened to 290-310 lb-ft torque if it becomes loose.

(15) Install the injector assembly. Swing the injector and valve rocker arms back into position and install the rocker arm brackets and tighten the bolts to 90-100 lb-ft torque. Adjust the valve clearance and time the injector. Rotate the crankshaft until the exhaust valves in the selected cylinder are open.

(16) Install the dial indicator again so the spindle of the indicator rests on top of the injector follower. Set the indicator dial to "O". Rotate the crankshaft slowly in the direction of rotation, and stop when the TDC mark on the vibration damper or crankshaft pulley lines up with the pointer.

(17) Note the reading on the dial indicator and compare with the following: If the indicator reading is .223 inch to .233 inch, the engine is in time; if the indicator reading is .188 inch to .204 inch, timing is one tooth retarded; if the indicator reading is .249 inch to .257 inch, timing is one tooth advanced.

(18) After completing the timing check, remove the dial indicator. Remove the shipping caps from the injector, and install the injector fuel

lines, making sure that they are tightened to prevent any leaks.

(19) Remove the pointer attached to the front of the engine.

(20) Adjust the exhaust valves and time the injectors as outlined in the Operator and Organizational Maintenance Manual, TM 55-1905-217-12 (para 4-28*e*).

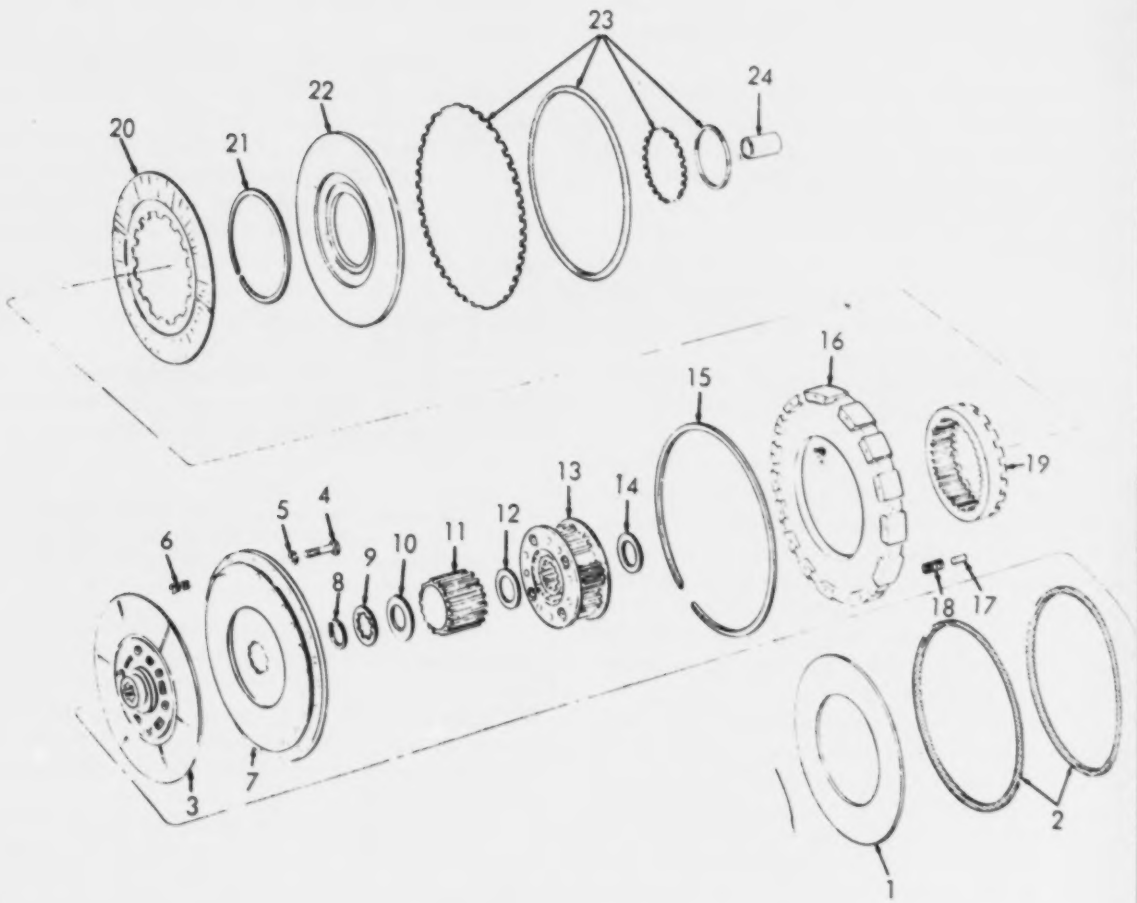
(21) Install the cylinder head rocker arm cover (para 3-8).

3-18. Oil Pan

a. Removal.

(1) Remove drain plug and drain oil into a suitable container TM 55-1905-217-12, (para 3-2).

(2) Remove the bolts (9), fig 3-69), lockwashers (6), and pry the oil pan (10) and gasket (11) loose from the block; maneuver it away from the engine and base. Remove all traces of the old gasket from both the pan and block.



ME 1905-217-34/3-69

1. Plug, pipe
2. Elbow
3. Hose
4. Elbow
5. Bolt
6. Lockwasher
7. Sump
8. Gasket
9. Bolt
10. Oil pan
11. Gasket

Figure 3-69. Oil pan, removal, disassembly, reassembly, and installation.

b. Disassembly. Remove drain plug (1), elbow (2), flexible hose (3), elbow (4), bolt (5), lockwasher (6), and remove the oil pan sump (7) and gasket (8), from the oil pan.

c. Cleaning and Inspection.

(1) Clean all metal parts of the oil pan assembly with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly.

(2) Inspect for damage, cracks, corrosion, and defective or missing hardware.

d. Repair.

(1) Remove rust and corrosion, straighten dents, and weld minor cracks and breaks.

(2) Replace gaskets and any defective parts as required.

(3) Replace an oil pan assembly that is damaged beyond repair.

e. Reassembly. Reassemble the oil pan assembly in reverse order of disassembly (*b* above).

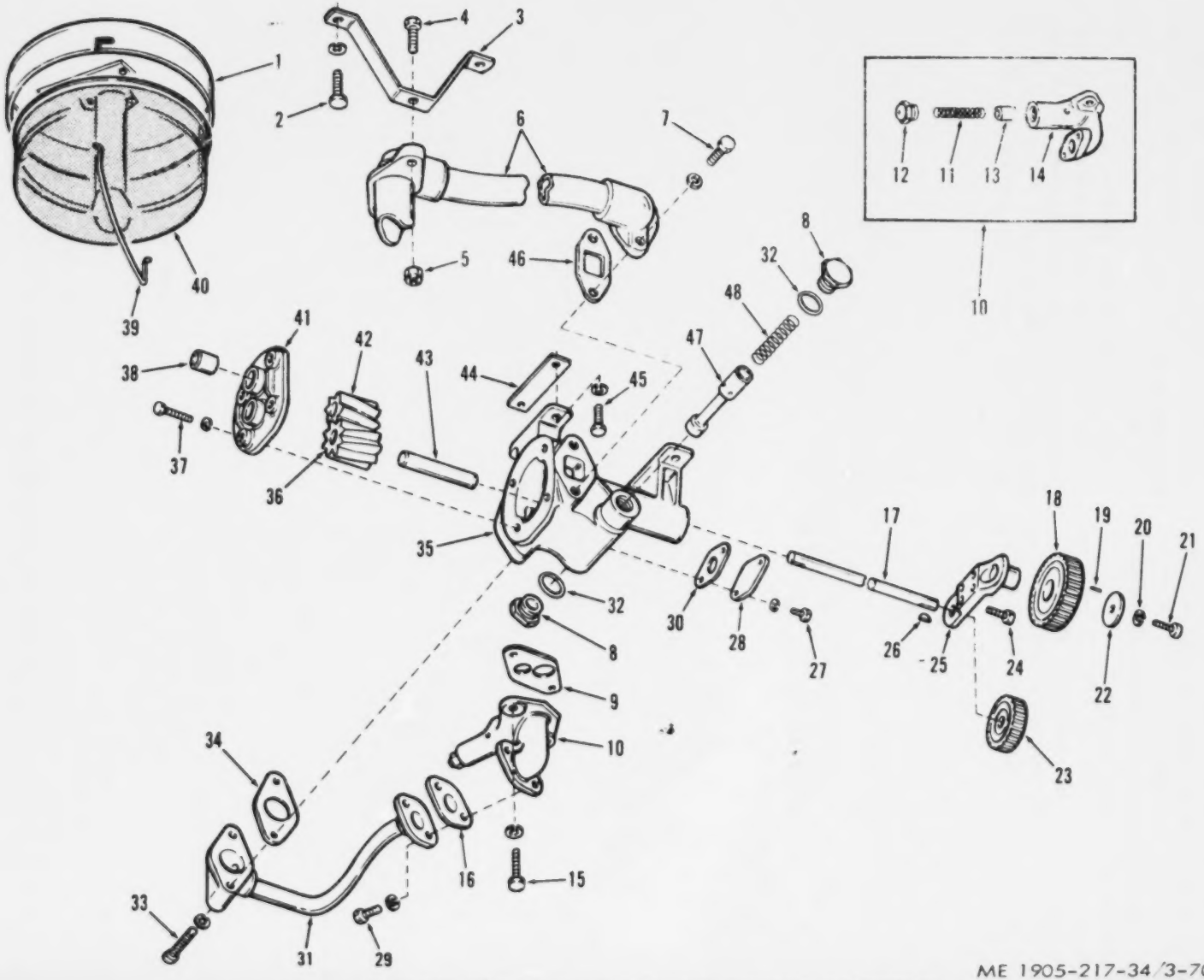
f. Installation. Install the oil pan in reverse order of removal (*a* above).

3-19. Oil Pump

a. Removal.

(1) Remove oil pan (para 3-18).

(2) Remove the bolts and lockwashers that mount the oil pump, regulator body, outlet tube, and inlet tube support, and remove oil pump assembly from the block and bearing caps. (fig. 3-70).



ME 1905-217-34/3-70

Figure 3-70. Oil pump, removal, disassembly, reassembly, and installation.

Key to figure 3-70.

1. Cover
2. Bolt
3. Screen bracket
4. Bolt
5. Nut
6. Pump inlet pipe
7. Bolt
8. Relief valve plug
9. Regulator to cylinder block gasket
10. Oil pressure regulator
11. Regulator spring
12. Regulator plug
13. Regulator valve
14. Regulator body
15. Bolt
16. Gasket
17. Drive shaft
18. Idler gear
19. Locating pin
20. Lock washer
21. Bolt
22. Washer
23. Gear
24. Bolt
25. Idler gear support
26. Woodruff key
27. Bolt, inlet pad cover
28. Inlet pad cover
29. Bolt
30. Gasket
31. Outlet pipe
32. Copper gasket
33. Bolt
34. Outlet pipe to pump gasket
35. Oil pump body
36. Driven gear
37. Bolt
38. Drive shaft bushing
39. Screen retainer
40. Pump screen
41. Pump cover
42. Drive gear
43. Driven gear shaft
44. Shim
45. Bolt
46. Inlet pipe to pump gasket
47. Oil pressure relief valve
48. Relief valve spring

NOTE

If shims were used between the pump mounting feet and bearing caps, note their location and save for installation.

b. *Disassembly.*

(1) Remove the oil pump inlet pipe (6, fig. 3- with the screen cover and mounting brackets.

(2) Remove the oil pressure regulator embly (10) and the oil pump outlet pipe (31) as assembly from the pump body (35).

(3) Remove valve plugs (8) and copper kets (32) from each side of the pump body, and the relief valve parts (47 and 48) from the mp body.

(4) Remove the pump driven gear (36) from driven gear shaft (43).

(5) Straighten the lip of the lock washer (20) and unscrew the bolt (21) thus freeing the idler gear (18).

(6) Clamp the pump body, drive shaft, and gear assembly in a bench vise. Pull the drive driven gear (23) from the outer end of the pump drive shaft using a gear puller.

(7) Remove the woodruff key (26) from the drive shaft and withdraw the shaft and driven gear (36) from the pump body.

(8) Unscrew the bolt (24) and remove the idler gear support (25) from the pump body.

(9) If the drive gear (42) is to be replaced, position the gear and shaft assembly on the bed of an arbor press with the long end of the shaft extending down through the slot in the bed plate and with the gear resting on the plate. Place a short (3 or 4 inches long) ½ inch round steel rod on the end of the shaft and press the shaft from the gear.

c. *Cleaning, Inspection and Repair.*

(1) Wash all parts in solvent (FED. SPEC PD-680) and dry them with compressed air.

(2) Examine the gear cavity in the pump body and the drive shaft bushings. If the driven gear bushings are worn, replace the bushings. Service replacement bushings in the driven gears must be reamed after assembly to 0.625 ± 0.0005 inches. If the gear housing is scored, a new pump body and cover should be installed.

NOTE

If the pump is to operate efficiently, the gears should have a free-running fit (no perceptible looseness) in the pump housing.

(3) If the gear teeth are scored or worn, install new gears. The use of excessively worn gears will result in low engine oil pressure which, in turn, may lead to serious damage throughout the engine.

(4) Inspect the pressure relief valve and its seat in the pump body. If necessary, install new parts.

(5) Check the pressure relief valve spring. Its free length is 2 23/64 inches and a load of 48 to 53 pounds should compress it to 1.5076 inches. If less than 48 pounds compresses it to this length, replace it.

d. *Reassembly.* Refer to figure 3-70 and assemble the oil pump as follows:

(1) Insert woodruff key (26) in the keyway of drive shaft (17) and apply a light coat of engine oil on the shaft. Start the shaft squarely into the bore of the gear (42) and press the shaft into the gear.

NOTE

The gear must be positioned on the shaft as shown in figure 3-71.

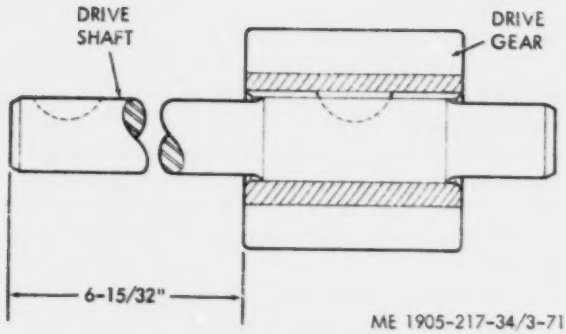


Figure 3-71. Oil pump drive shaft and gear assembly.

(2) Place the idler gear support (25) in position against the forward end of the pump body and secure the support to the body with bolt (24).

(3) Install the drive gear and shaft assembly in the pump body and slide the driven gear (36) onto the shaft (43).

(4) Secure the pump cover (41) to the oil pump body with four bolts (37) and lock washers.

(5) Support the drive gear end of the drive shaft (17) on the bed of an arbor press and insert the woodruff key (26) in the keyway of the shaft. Position the drive-driven gear (23) on the end of the drive shaft with the extended hub side up away from the pump body. Insert a .005 inch feeler ribbon between the driven gear and the pump body. Press the gear along the shaft until the clearance between the gear and the body is .005 inches.

(6) If locating pin (19) was removed, install it in the idler gear support (25), then lubricate the bearing surface with engine oil and place gear (18) in position on the support (25) with the flat side of the gear facing the support.

(7) Place the lock washer (20) on the bolt (21) and the special washer (22) next to the lock washer, then start the bolt into the idler gear support. Rotate the special washer and lock washer so that the slot in each washer engages the locating pin (19).

(8) Tighten the idler gear bolt so the bolt head is over the end of the locating pin, then bend the lock washer against one flat of the bolt head.

(9) Screw the relief valve plug (8), with copper gasket (32), into place in the side of the pump body opposite the inlet opening. Then place the valve (47) and spring (48) in the bore at the inlet side of the pump body. While compressing the spring, start the second relief valve plug (8) with gasket (32), into the body. Tighten both plugs.

e. Replacement of Oil Pump Drive Gear on Crankshaft.

(1) Use gear puller J 3051 to remove this gear after removing crankshaft front cover and oil slinger.

(2) A new gear may be installed, after the woodruff key is placed in the crankshaft key slot, by tapping gear into position against the shoulder on the crankshaft with a large sleeve and mallet. Then place the oil slinger on the crankshaft with the dish side away from the gear and replace the front cover.

f. Installation. Refer to figure 3-70 and install the oil pump on the main bearing caps as follows:

(1) Hold the pump assembly against the main bearing caps so the idler gear (18) meshes with the driving gear on the crankshaft.

(2) Insert the four bolts (45) with lock washers through the mounting feet of the pump and into the main bearing caps. Align the pump so that the teeth of the crankshaft gear and the idler gear are parallel; then tighten the bolts to 35-39 lb-ft and check clearance between the gear teeth with a feeler gage. Proper clearance between the crankshaft gear and idler gear is .002 inch minimum, .012 inch maximum.

NOTE

If shims were used between the pump mounting feet and the bearing caps and new gears are not installed, the same shims (cleaned) or the same number of new (identical) shims should be installed and the number then adjusted to obtain the proper clearance between gear teeth. However, if new gears have been installed, a larger number of shims will be required under the mounting feet. In either event, the pump must be tightened on the bearing cap before the clearance between the gear teeth is measured. When adjusting for gear tooth clearance by installing or removing shims, the the same number of shims must be changed under each foot so that the pump will always be level on the main bearing caps. The insertion or removal of one .005 inch shim will change the gear tooth clearance by .0035 inch.

(3) Place a new gasket (16) between the outlet pipe and the pressure regulator and bolt the two parts together loosely. Use a new gasket (34) and secure the outlet pipe (31) to the oil pump body (35) with the bolts (33). Attach the pressure regulator (10) to the cylinder block using a new gasket (9).

NOTE

When attaching the pump outlet and the pressure regulator, none of the bolts should be tightened until all the bolts have been started. After all bolts are started, the outlet pipe bolts (33) should be tightened alternately, then the pressure regulator bolts (15) should be tightened, and finally the pipe-to-regulator bolts (29) should be secured. This procedure prevents twisting the outlet pipe.

(4) Attach the pump screen brackets (3) to the main bearing caps with lock washers and bolts (2). Do not tighten the bolts.

(5) Affix a new gasket (46) to the pump end of the inlet pipe (6), then attach the pipe to the oil pump.

(6) Set the screen cover (1) over the outer end of the oil inlet pipe (6) and secure it to the pipe and brackets (3) with bolts (4). Tighten the bracket bolts (2) to the bearing caps.

(7) Place the screen (40) in the cover (1) and lock it in place with retainer (39).

(8) Recheck all bolts for tightness to assure there will be no leaks in the oil pump and pipe mounting connections.

(9) Place a new gasket on the oil pan and install the oil pan on the cylinder block. All the oil pan bolts should be started before any are tightened. Bolts should be tightened snugly but not excessively, starting w :h the center bolts and working toward each end o the oil pan. Excessive tightening of the bolts will crush the oil pan gasket unnecessarily.

3-20. Pistons and Connecting Rods

a. Removal.

(1) Drain lubricating and cooling systems (TM 55-1905-217-12, para 3-2).

(2) Remove cylinder head (para 3-13).

(3) Remove oil pump (para 3-19).

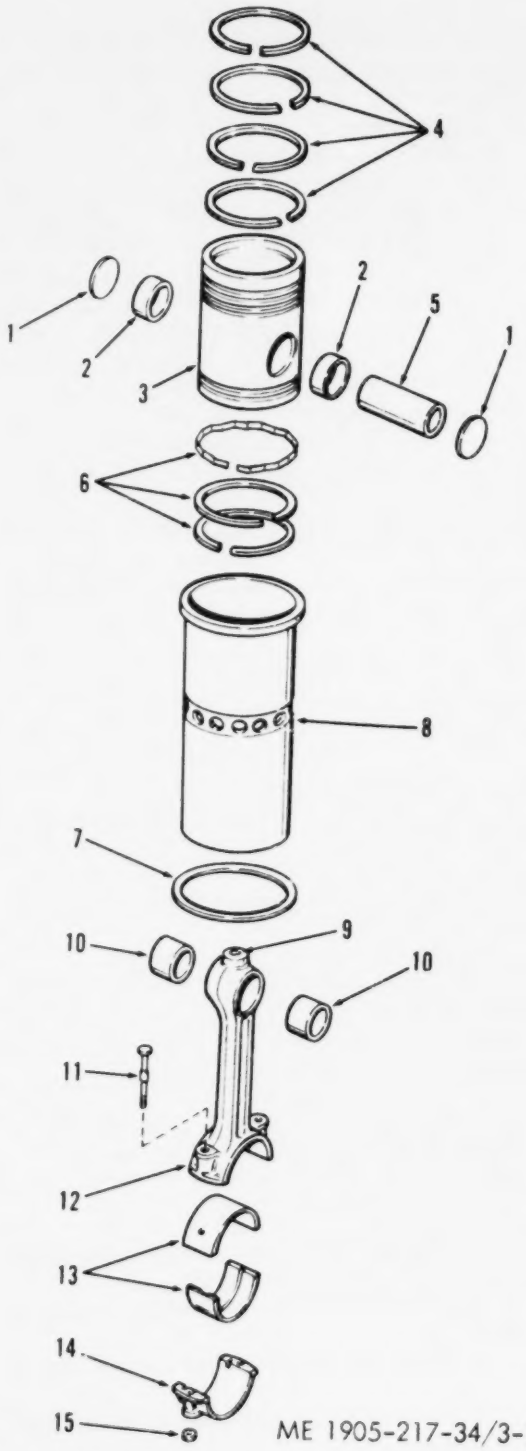
(4) Remove the carbon deposits from the upper inner surface of the cylinder liner.

(5) Use a ridge cutter to remove any ridge in the cylinder liner at the top of the piston ring travel.

NOTE

Move the piston to the bottom of its travel and place a cloth over the top of the piston to collect the cuttings. After the ridge has been removed, turn the crankshaft to bring the piston to the top of its stroke and carefully remove the cloth with the cuttings.

(6) Remove nut (15), bolt (11), and the bearing cap (14, fig. 3-72) and lower bearing shell from the connecting rod. Then, push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.



1. Piston pin retainer
2. Bushing
3. Piston
4. Piston rings, compression
5. Piston pin
6. Piston rings, oil control
7. Cylinder sleeve gasket
8. Cylinder sleeve
9. Oil nozzle
10. Bushing
11. Bolt
12. Connecting rod
13. Bearing
14. Connecting rod bearing cap
15. nut

Figure 3-72. Piston, connecting rod and cylinder sleeve, removal, disassembly, reassembly, and installation.

(7) With the connecting rod and piston removed from the cylinder block, reassemble the bearing cap and lower bearing shell to the connecting rod.

b. Disassembly.

(1) Secure the connecting rod (12, fig. 3-72) in a vise equipped with soft jaws and remove the piston rings (4) with tool J 8128.

(2) Punch a hole through the center of one of the piston pin retainers (1) with a narrow chisel or punch and pry the retainer from the piston. Use care to prevent damage to the piston and bushings.

(3) Withdraw the piston pin (5) and free the piston (3) from the connecting rod (12).

(4) Drive the remaining piston pin retainer out from the inside with a brass rod or other suitable tool.

(5) The piston pin bushings may be removed with tool set 1513-02 by placing the piston in holding fixture J-1513-1. Make sure bushing bore is in alinement with the hole in the base of the fixture.

(6) Drive the bushings (2) out of the piston with remover J 1513-3 and handle J 1513-2.

(7) Clamp the upper end of the connecting rod in holder J 7632 so the bore in the bushings is in line with the hole in the base of the holder.

(8) Set bushing remover J 1513-3 in connecting rod bushing, insert handle J 1513-2 in remover and drive bushings (10) from the rod.

(9) If necessary to replace the spray nozzle, remove old nozzle as follows:

(a) Remove piston pin bushings.

(b) Insert spray nozzle remover J-8995 through the upper end of the connecting rod and insert the pin in the curved side of the remover in the opening in the bottom of the spray nozzle.

NOTE

The spring pin in the lower end of the drilled passage in the connecting rod is not serviced separately, and it is not necessary to remove it when replacing the spray nozzle.

(c) Support the connecting rod and spray nozzle remover in an arbor press.

(d) Place a short sleeve directly over spray nozzle.

(e) Press the nozzle out of the connecting rod.

(f) Remove the spray nozzle removing tool.

c. Cleaning.

(1) After removing the piston rings from the piston and the piston for the connecting rod, clean the parts with solvent, (FED. SPEC. PD-680) and dry them with compressed air. If the solvent does not remove the carbon deposits, use a chemical solvent which will not harm the piston pin bushings or the tin plate on the piston.

(2) The upper part of the piston, including the compression ring lands and grooves, is not tin plated and may be wire-brushed to remove any hard carbon. However, care must be taken to avoid damaging the tin plating on the piston skirt. Clean the ring grooves with a piece of used compression ring that has been ground to a bevel edge or another suitable tool.

(3) Clean the cooling surfaces on the inside of the piston and the oil return holes in the lower half of the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

(4) Clean the connecting rods and piston pins with cleaning solvent FED. SPEC. PD-680 and dry with compressed air.

d. Inspection and Repair.

(1) If the tin plate on the piston and the original grooves in the piston rings are intact, it is an indication of very little wear.

(2) Excessively worn or scored pistons, rings and cylinder liners may be an indication of abnormal maintenance or operating conditions and these conditions should be corrected as soon as possible.

(3) Examine the piston for score marks, cracks, damaged ring groove lands, or indications of overheating. A piston with light score marks which can be cleaned up may be reused. Any piston that has been severely scored, overheated or burned must be replaced. Indications of overheating or burned spots on the piston may be the result of an obstruction in the connecting rod oil passage, which interrupted the flow of oil to the spray nozzle.

(4) Check the cylinder liner and block bore for excessive out-of-round, taper, or high spots which could cause piston failure.

(5) Other factors that contribute to piston failure include oil leakage into the air box, oil pullover from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

(6) If the piston is to be reused, measure the piston pin bushings and the piston pin. The inside diameter of a new bushing in the piston is 1.5025 inches to 1.5030 inches, and the outside diameter of a new piston pin is 1.4996 inches to 1.5000 inches. The piston pin-to-bushing clearance with new parts is .0025 inch to .0034 inch. A maximum clearance of .010 inch is allowable with worn parts.

(7) Inspect rod and piston pin for visible fractures (hairline). Any detectable fractures require that the rod or pin be replaced.

(8) Examine the spray nozzle at the upper end of the connecting rod to make sure the holes are open. Blow dry compressed air through the drilled oil passage in the rod to be sure it is open.

(9) Check the connecting rod bushings for ndications of scoring, overheating, or other amage. Bushings that have overheated may ecome loose and creep together, thus blocking ff the supply of lubricating oil to the piston pin nd spray nozzle.

(10) Since it is subjected to downward oading only, free movement of the piston pin is esired to secure perfect alignment and uniform ear. Therefore, the piston pin is assembled with full floating fit in the connecting rod and piston ushings, and with relatively large clearances. Vorn piston pin clearances up to .010 inch are atisfactory. Measure the outside diameter of the iston pin to determine the amount of wear. The iameter of a new standard size piston pin is .4996 inches to 1.5000 inches.

(11) The inside diameter of a new connecting od bushing is 1.5015 inches to 1.5020 inches. The pecified clearance between the piston pin and onnecting rod bushings is .0015 inch to .0024 nch with new parts.

e. Reassembly. With the connecting rod lamped in holder J 7632 as outlined above, in- tall the new bushings as follows:

(1) *Connecting Rod Bushing Installation.*

(a) Start one of the bushings straight into he bore of the connecting rod.

NOTE

The bushing joint must be toward the top of the connecting rod.

(b) Insert bushing installer J 1513-6 in the ushing. Then, insert handle J 1513-2 in the nstaller and drive the bushing in until the flange f the installer bottoms on the connecting rod.

(c) Turn the connecting rod over in the nolder, aline the bore in the rod with the hole in the base of the tool, and install the second bushing in the same manner.

(2) *Ream Bushings in Connecting Rod.* Service replacement bushings must be reamed to size, using tool set J 2686-02, in the following manner:

(a) Clamp reaming fixture J 1686-9 in a bench vise (fig. 3-73).

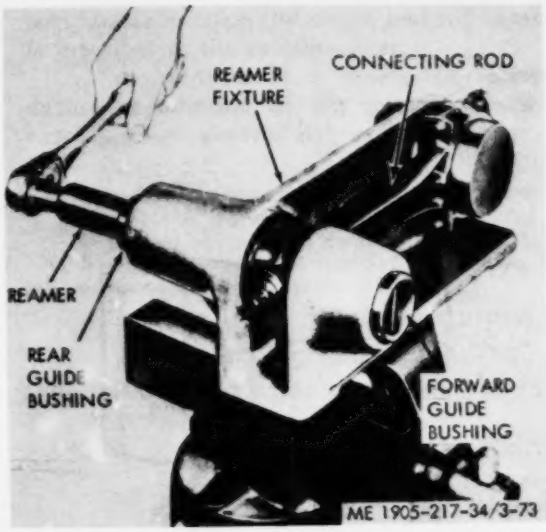


Figure 3-73. Reaming piston pin bushings in connecting rod.

(b) Place the large end of the connecting rod over the arbor of the fixture and tighten the connecting rod cap nuts to 60-70 lb-ft torque.

(c) Slide forward guide bushing J 1686-11 into the front guide boss with the pin end facing out.

(d) Aline the upper end of the connecting rod with the opening in the reaming fixture.

(e) Install rear guide bushing J 1686-5 on reamer J 1686-10, and insert the reamer and bushing through the rear guide boss of the fixture.

(f) Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer.

(g) Remove the reamer and the connecting rod from the fixture, blow out the chips, and measure the inside diameter of the bushings. The inside diameter of the bushings must be 1.5015 inches to 1.5020 inches to provide a clearance of .0015 inch to .0024 inch with a new piston pin.

(3) *Install Spray Nozzle in Connecting Rod.*

(a) Start the spray nozzle, with the holes positioned as shown in figure 3-74, straight into the counter bore in the top of the connecting rod.

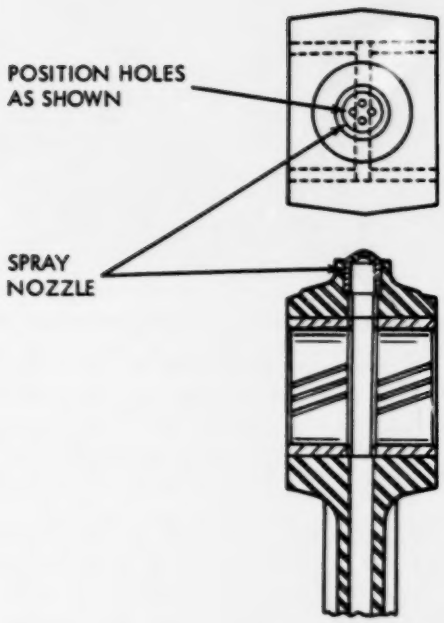


Figure 3-74. Installation of spray nozzle in connecting rod.

(b) Support the connecting rod in an arbor press. Then, place a short 3/8 inch I.D. sleeve on top of the spray nozzle and under the ram of the press.

(c) Press the spray nozzle into the connecting rod until it bottoms in the counterbore.

(d) Install new bushings in the connecting rod.

(4) *Install Bushing in Piston.*

(a) Place the spacer J 1513-4 in the hole in the fixture J 1513-1.

(b) Set the piston on the fixture so the spacer protrudes into the bushing bore.

(c) Insert the installer J 1513-6 in a bushing. Then, position the bushing and installer over the lower bushing and installer over the lower bushing bore.

NOTE

The bushing joint should be located toward the bottom of the piston.

(d) Insert the handle J 1513-2 in the bushing installer and drive and bushing in until it bottoms on the spacer.

(e) Install the other bushing in the same manner.

(5) *Ream Bushings in Piston.* The piston bushings must be reamed after installation in the piston. Proceed with reaming tool set J 3071-01 as follows:

(a) Clamp the piston bushing reaming fixture J 5273 in a vise. Then, insert the guide bushing J 3071-7 in the fixture and secure it with the setscrew.

(b) Place the piston in the fixture and insert the pilot end of the reamer J 3071-6 through the clamping bar, piston pin bushings, and into the guide bushing.

(c) With the piston, fixture, and reamer in alignment, tighten the wing nuts securely.

(d) Ream the bushings. Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For best results, use only moderate pressure on the reamer.

(e) Withdraw the reamer and remove the piston from the fixture. Remove the chips with compressed air and measure the inside diameter of the bushings. The diameter must be 1.5025 inches to 1.5030 inches.

(6) *Fitting Piston.* Measure the piston diameter, cylinder liner bore, and block bore, preferable at room temperature (70° F).

(a) The piston skirt diameter must be measured lengthwise and crosswise of the piston pin bore. The taper and out-or-round, measured from a point approximately 1.88 inches from the top of the piston to the bottom of the piston, must not exceed .0005.

(b) A new cylinder liner has an inside diameter of 4.2495 inches to 4.2511 inches throughout the entire length. Therefore, with new parts, the piston-to-liner clearance will vary with the particular piston diameter. A maximum clearance of .012 inches is allowable with used parts.

(c) Hold the piston upside down in the cylinder liner and check the piston-to-liner clearance. To avoid inaccurate readings, the liner must be placed in the cylinder block. Check the clearance in four places, 90 ° apart.

(d) Feeler gage set J 5438 may be used for checking the piston-to-liner clearance. The set consists of a feeler gage pack J 3174-01, a spring scale J 8129, and a swivel connection J 593-14. The spring scale, attached to the appropriate feeler gage, is used to measure the amount of force in pounds required to withdraw the feeler gage from between the piston and liner.

(e) Select a feeler gage with a thickness that will require a pull of six pounds to remove. The piston-to-liner clearance will be .001 inch

ater than the thickness of the feeler gage used, , a .004 inch feeler gage will indicate a .050 h clearance when it is withdrawn with a six nd pull. The feeler gage must be perfectly flat, l free of nicks and bends.

(f) If any bind occurs between the piston l liner, remove the piston and examine the ton and liner for burrs. Remove burrs with a e hone (a flat one is preferable) before ceeding with the clearance check.

(7) *Fitting Piston Rings.* All new piston rings st be installed whenever a piston is removed, gardless of whether a new or used piston or inder liner is installed.

(a) Insert one ring at a time inside of the inder liner and far enough down in the bore to within the normal area of the ring travel. Use a ton to push the ring down to be sure it is rallel with the top of the liner. Then, measure e ring gap with a feeler gage. The ring gaps are ecified in table 1-2.

(b) If the piston ring gap is insufficient, it y be increased by filing or stoning the ends of e ring. File or stone both ends of the ring so the tting action is from the outer surface to the ner surface. This will prevent any chipping or eling of the chrome plate on the compression g. The ends of the ring must remain square and e chamfer must be approximately .015 inch on e outer edge.

(c) Check the ring clearance in the piston g grooves. The piston ring clearances are own in table 1-2.

(8) *Assemble Rings on Piston.* Refer to figure 2 for the locations of the rings on the piston.

NOTE

Before installing rings, the connecting rod and piston should be assembled.

(a) Install the compression rings on the ston with tool J 8128. To avoid breaking or erstressing the rings, do not spread them any re than necessary to slip them over the piston.

(b) Install the oil control rings by hand. e scraping edges must face toward the bottom the piston for proper oil control. First, install e expander carefully in the upper oil ring oove. Next, install the top ring with the gap 0° from the gap in the expander. Then, install e bottom ring with the gap 45° from the gap of e upper ring. Install the second oil control ring the lower oil ring groove in the same manner.

(c) When installing the oil control rings, re must be exercised to prevent overlapping the ds of the oil control ring expanders. The ex- nders must be correctly seated inside the piston control ring grooves. An overlapped expander ll cause the oil control ring to protrude beyond owable limits. A protruding oil control ring will be broken when the piston is installed in a ring compressor or when the piston and rod assembly is installed in the cylinder liner.

(d) If there is a noticeable resistance during installation of the piston, check for overlapped oil control ring expander ends.

NOTE

Do not cut or grind off the ends of the oil ring expanders to keep them from overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control ring and result in high lubricating oil consumption.

(9) *Assemble Connecting Rod to Piston.* Apply clean engine oil to the piston pin and bushings. Assemble the connecting rod to the piston as follows:

(a) Rest the piston in the holding fixture J 1513-1.

(b) Place a new piston pin retainer in position. Then, place the crowned end of installer J 4895-01 against the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly in the piston.

NOTE

Do not drive the retainer in too far or the piston pin bushing may be moved inward and result in reduced piston pin end clearance.

(c) Place the upper end of the connecting rod between the piston pin bosses and in line with the piston pin holes. Then, slide the piston pin in place. If the piston pin-to-bushing clearances are within the specified limits, the pin will slip into place without use of force.

(d) Install the second piston pin retainer as outlined in steps (*a*) and (*b*).

(e) After the piston pin retainers have been installed, check for piston pin end clearance by "cocking" the connecting rod on the pin and shifting it in its bushings.

(f) One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushings, from reaching the cylinder walls. Check the retainers for proper sealing as follows:

1. Place the piston and connecting rod assembly upside down on a bench.

2. Pour clean fuel oil in the piston to a level above the piston pin bosses.

3. Dry the external surfaces of the piston in the area around the retainers, and allow the fuel oil to set for about fifteen minutes.

4. Check for seepage of fuel oil around the retainers. If the fuel oil leads around the retainers, install new retainers. In extreme cases, it may be necessary to replace the piston.

5. After the leakage test is completed, empty the fuel oil from the piston, dry the parts

with compressed air, and lubricate the piston pin with clean engine oil.

(g) Install the piston rings on the piston.

f. Installation.

(1) Install connecting rods (12, fig. 3-72) and bearings (13), and bearing caps (14) on the crankshaft.

(2) Install oil pump (para 3-19).

(3) Install cylinder head (para 3-13).

(4) Fill lubricating and cooling systems TM 55-1905-217-12. (para 3-2 and 4-2).

3-21. Cylinder Liners

a. Removal. Remove a cylinder liner from the block as follows:

(1) Remove the piston and connecting rod assembly (para 3-20).

(2) Remove the liner with tool J 1918-02 as follows:

CAUTION

It is very important that the proper method is followed when removing a liner. Do not attempt to push the liner out by inserting a bar in the liner ports and rotating the crankshaft, otherwise the piston may be damaged or the upper ring groove may collapse.

(a) Slip the lower puller clamp up on the puller rod and off the tapered seat. Cock the clamp so it will slide down through the liner. The clamp will drop back on the tapered seat after it clears the bottom of the liner. Then, slide the upper puller clamp down against the top edge of the liner.

(b) With the tool in place, strike the upset head on the upper end of the puller rod a sharp blow with the puller weight, thus releasing the liner (figure 3-75).

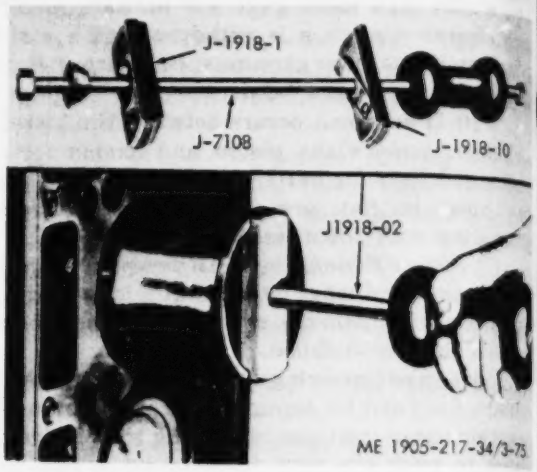


Figure 3-75. Cylinder liners, removal.

(c) Remove the tool from the liner. Then remove the liner from the block.

(d) Remove the liner insert from the counterbore in the block.

b. Cleaning. Clean the cylinder liners with cleaning solvent (FED. SPEC. PD-680), and dry thoroughly.

c. Inspection of Used Cylinder Liner.

(1) When the cylinder liner is removed from the cylinder block, it must be thoroughly cleaned and then check for: cracks, scoring, poor contact on outer surface, flange irregularities, inside diameter, out-of-round and taper.

(2) A cracked or excessively scored liner must be discarded. A slightly scored liner may be cleaned-up and reused.

(3) Excessive liner-to-block clearance or block bore distortion will reduce heat transfer

om the liner to the block and to the engine olant. Poor contact between the liner and the ock bore may be indicated by stains or low essure areas on the outer surface of the liner ig. 3-76).

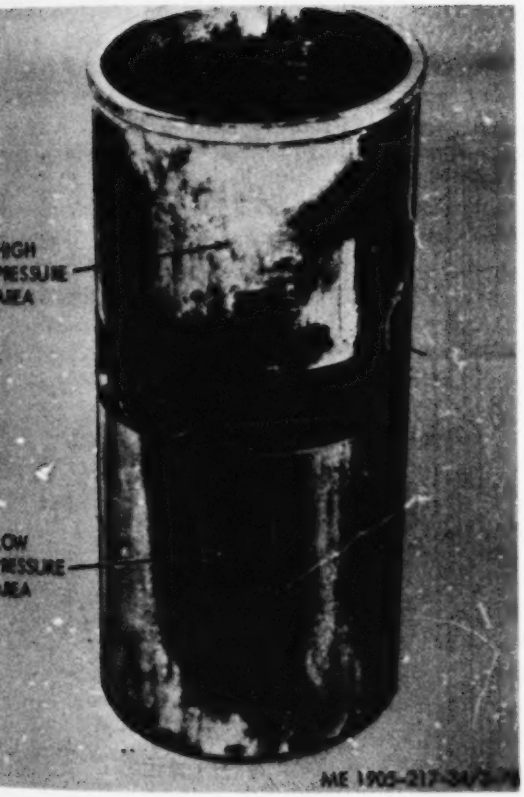


Figure 3-76. *High and low pressure contact areas on cylinder liner.*

(4) Examine the outside diameter of the liner for fretting. Fretting is the result of a slight movement of the liner in the block bore during engine operation, which material from the block to adhere to the liner. These metal particles may be removed from the surface of the liner with a coarse, flat stone.

(5) The liner flange must be smooth and flat on both the top and bottom surfaces. Check for cracks at the flange. The liner insert must also be smooth and flat on the top and bottom surfaces. Replace the insert if there is evidence of brinelling (cracking of surface).

(6) Measure the inside diameter of the liner at the various points indicated in figure 3-77. Use cylinder bore gage J 5347, which has a dial indicator calibrated in .0001 inch increments, as it is rather difficult to obtain accurate measurements with a micrometer. Set the cylinder bore gage to zero in master ring gage J 5580-1. Also, check the liner for taper and out-of-round. Measurements must be made with the liner installed in the proper bore of the cylinder block.

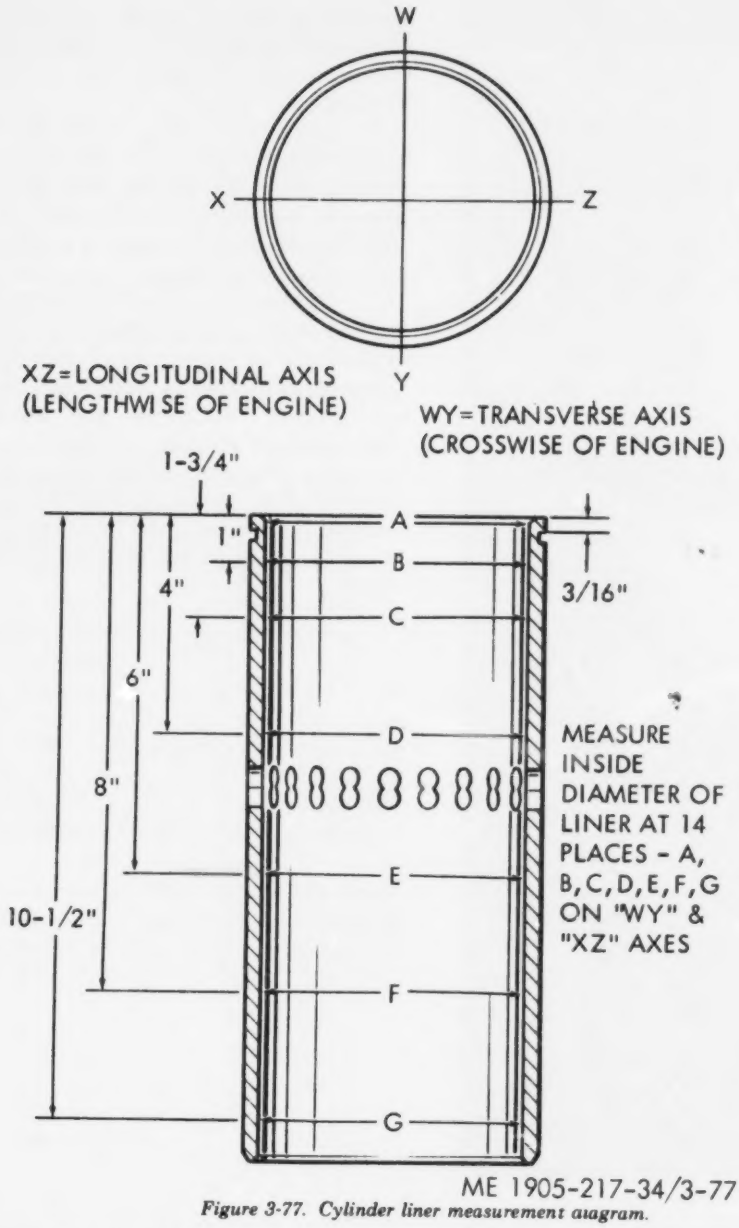


Figure 3-77. Cylinder liner measurement diagram.

(7) To reuse the liner, the taper must not exceed .002 inch and the out-of-round must not exceed .003 inch. In addition, the ridge formed at the top of the ring travel must be removed. If the out-of-round exceeds .002 inch, rotate the liner 90° in the block bore and recheck. A service liner is available only with a standard inside diameter of 4.2495 inches to 4.2511 inches.

d. Honing Used Cylinder Liner. A used cylinder liner must be honed. To break the glaze which results after long periods of operation and to remove the ridge formed at the top by the piston ring travel.

(1) When a liner has been in service for a long period, the bore becomes very smooth or glazed due to the rubbing action of the piston rings. Unless this glaze is removed, the time required to seat new piston rings will be lengthened.

(2) The ridge formed at the top of the liner by the travel of the piston rings must also be removed. Otherwise, interference with the travel of the new compression rings may result in ring

breakage. Therefore, even through the taper and out-of-round are within the specified limits, the glaze and ridge must be removed by working a hone up and down the full length of the liner a few times.

(3) Whenever a liner is honed, it should be placed in a fixture (a scrap cylinder block makes an excellent honing fixture). However, if it is necessary to hone a liner in the cylinder block that is to be used in building up the engine, the engine must be dismantled and then, after honing, the cylinder block and other parts must be thoroughly cleaned to ensure that all abrasive material is removed.

(4) Use 120 grit stones and hone the liner in a criss-cross pattern that produces hone marks on a 45° axis. This operation may be performed with emery cloth if a hone is not available.

(5) After the liner has been honed, remove it from the fixture and clean it thoroughly. Then, dry it with compressed air and check the entire surface for burrs.

(6) After honing, the liner must conform to the same limits on taper and out-of-round as a new liner, and the piston-to-liner clearance must be within the specified limits shown in table 2, chapter one.

e. Inspection of New Cylinder Liner. Install the cylinder liner in place in the cylinder block and check it for: Inside diameter, out-of-round, and taper. Check the inside diameter at the various points shown in figure 3-77. The inside diameter of a new standard size liner is 4.2495 inches to 4.2511 inches. If the liner is more than .002 inch total indicator reading out-of-round, turn it 90° in the block bore and recheck. A new liner must also be straight from top to bottom within .001 inch. Refer to table 2, chapter one for the specified piston-to-liner clearance.

NOTE

Do not modify the surface finish in a new service liner. Since the liner is properly finished at the factory, any change will adversely affect the seating of the piston rings.

f. Fitting Cylinder Liner in Block Bore. The top face of the cylinder liner flange must be .0465 inch to .050 inch below the top surface of the cylinder block to provide proper sealing of the cylinder head compression gasket. Install the liner in the block and proceed as follows:

(1) Wipe the inside and outside of the liner clean, and make sure the counterbore in the block is clean, so the liner insert will seat properly. The counterbore must be from .4785 inch to .4795 inch in depth and must not vary more than .001 inch in depth around the circumference.

(2) Place a liner insert in the counterbore of the block (fig. 3-78).

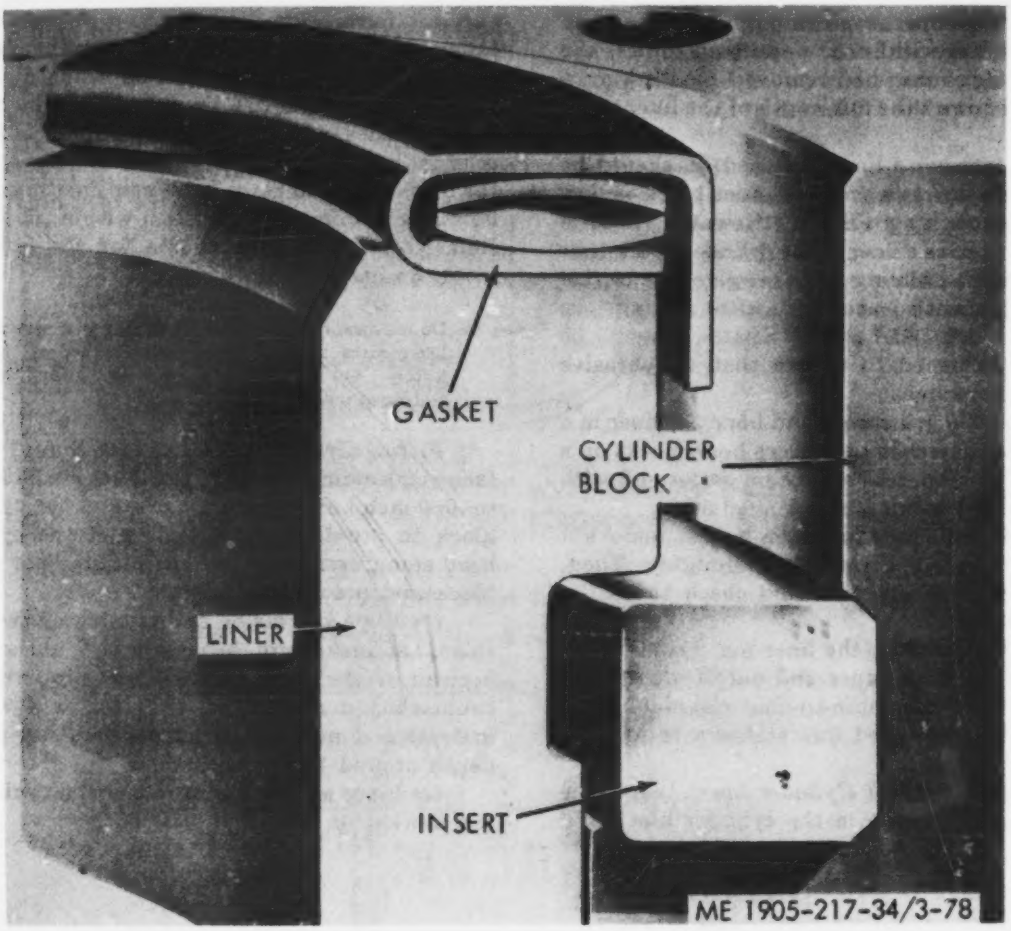


Figure 3-78. Cylinder liner mounting in block.

(3) Push the liner into the cylinder block until the liner flange rests on the insert. If the liner and block bore measurements are within specifications, the liner will slide smoothly in place. If it does not slide freely into place, withdraw the liner and turn it 90° and reinstall it. Do not force the liner into place.

(4) Clamp the liner in place with hold-down clamps J 21793.

(5) Measure the distance from the top of the liner to the top of the block with a dial indicator. The liner flange must be .0465 inch to .050 inch below the surface of the block. However, even though all of the liners are within these specifications, there must not be over .002 inch difference in depth between any two adjacent liners. If the above limits are not met, install the liner in another cylinder and recheck, or use a new liner.

(6) Matchmark the liner and block with chalk or paint so the liner may be reassembled in the same position in the block bore. The matchmarks should be toward the blower side of the engine.

(7) Remove the holddown clamps and the liner.

NOTE

Do not remove the liner insert.

g. Installation.

(1) Piston and Connecting Rod Assembly.

(a) With the piston assembled to the connecting rod and the piston rings in place as outlined in paragraph 3-20, apply clean engine oil to the piston, rings, and inside surface of the piston ring compressor J 3272-02.

CAUTION

Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

(b) Place the piston ring compressor on top of a wood block, with the tapered end of the ring compressor facing up.

(c) Position (stagger) the piston ring gaps properly on the piston. Make sure the ends of the oil control ring expanders are not overlapped.

(d) Start the top of the piston straight into the ring compressor. Then, push the piston down until it contacts the wood block ("Operation 1" of fig. 3-79).

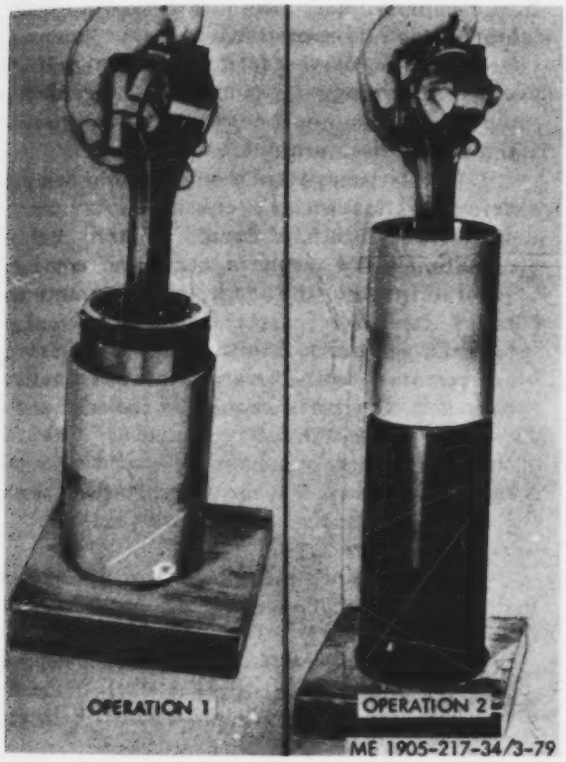


Figure 3-79. Installing piston and connecting rod assembly in cylinder liner.

NOTE

The numbers on the side of the connecting rod and cap identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification number must be stamped in the same location as on the connecting rod that was replaced.

(e) Push the piston and connecting rod assembly down into the liner until the piston is free of the ring compressor.

CAUTION

Do not force the piston into the liner. The peripheral abutment type expanders apply considerable more force on the oil ring than the standard expander. Therefore, extra care during the loading operation must be taken to prevent ring breakage.

(f) Remove the connecting rod cap and the ring compressor. Then, push the piston down until the compression rings pass the liner ports.

(2) Cylinder Liner, Piston and Connecting Rod Assembly. After the piston and connecting rod assembly have been installed in the cylinder liner, the entire assembly may then be installed in the engine as follows:

(a) If any of the pistons and liners are already in the engine, use holddown clamps, J 21793, to retain the liners in place when the crankshaft is rotated.

(b) Rotate the crankshaft until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel. Wipe the journal clean and lubricate it with clean engine oil.

(c) Install the upper bearing shell (the one with a short oil groove at each parting line) in the connecting rod. Lubricate the bearing shell with clean engine oil.

(d) Hold the piston, connecting rod, and liner in line with the block bore so the identification numbers on the connecting rod face the blower side of the engine, and the matchmarks on the liner and the block are in alignment. Carefully guide the end of the connecting rod into the block bore so the bearing shell will not be dislodged. Then, slide the piston, connecting rod, and liner assembly into the block bore until the liner flange rests against the insert in the counterbore in the block.

(e) Push or pull the piston and connecting rod into the liner until the upper bearing shell is firmly seated on the crankshaft journal.

(f) Place the lower bearing shell (the one with the continuous oil groove from one parting line to the other) in the connecting rod bearing cap, with the tang on the bearing shell in the notch in the bearing cap. Lubricate the bearing shell with clean engine oil.

(g) Install the bearing shell and cap on the connecting rod with the identification numbers adjacent to each other. Tighten the connecting rod bolt nuts to 60-70 ft-lb. torque.

(h) Check the connecting rod side clearance. The clearance must be .006 inch to .012 inch.

(i) Install the remaining liner, piston and rod assemblies in the same manner.

(j) After all of the liners and pistons have been installed, remove the holddown clamps.

(k) Install the compression gaskets and water and oil seals prior to reassembling the cylinder head to the cylinder block. (para 3-13).

3-22. Crankshaft Pulley, Vibration Damper and Front Oil Seal

a. General. The front oil seal is pressed into the crankshaft front cover and the lip of the seal bears against the vibration damper inner cone. If oil

should leak past the seal, the seal must be replaced.

b. Removal. If necessary, the front oil seal may be removed without removing the front cover. Proceed as follows:

(1) Remove the front power take-off (outboard engine only).

(2) Remove bolt and washer from end of crankshaft. Partially reinstall the bolt.

(3) Use a puller as shown in figure 3-80 to remove the pulley.

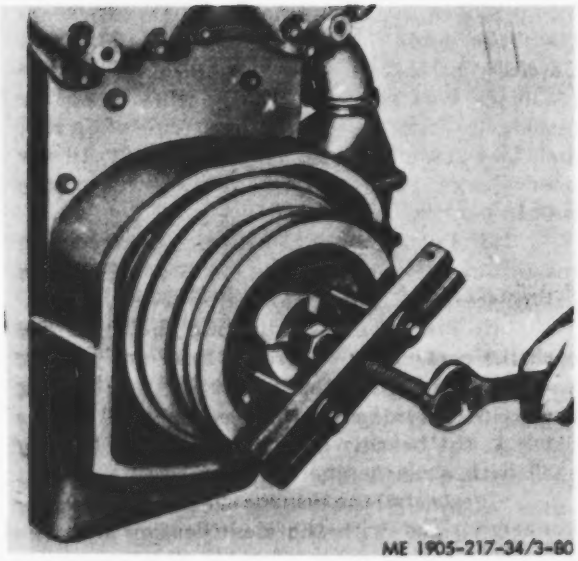


Figure 3-80. Crankshaft pulley, removal.

(4) Remove two damper-to-hub bolts and lock washers diametrically opposite to each other.

(5) Reinstall the pulley crankshaft bolt and install a puller to loosen the outer cone wedged between the crankshaft and the damper hub. After loosening the cone it may be "fished" from the inner diameter of the damper hub with two thin shank screw drivers.

(6) Slide the dampers with damper hub as an assembly off the end of the crankshaft.

(7) Slide the inner cone from the crankshaft.

(8) Drill two holes directly opposite each other in the seal casing and install metal screws with flat washers. Remove the seal by prying against the flat-washers with suitable pry bars.

c. Cleaning. Clean damper and pulley with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly.

d. Inspection.

(1) Inspect the damper to see that the rubber is firmly bonded to the metal parts at each side. If the damper has been exposed to solvent, lubricating oil or excessive heat, the rubber may have become loosened from the metal. In this event, the damper should be discarded and replaced with a new one. Also, check to see that the metal discs are not bent.

(2) If damage to the vibration damper is extensive, inspect the crankshaft. A loose or defective vibration damper, after extended operation, may result in a cracked crankshaft.

(3) Inspect the damper inner and outer cones, damper hub and the end of the crankshaft for galling or burrs. Slight scratches or burrs may be removed with emery cloth. If seriously damaged, the parts should be replaced and the end of the crankshaft refinished. Check the outside diameter of the inner cone for wear at the crankshaft front oil seal contact surface. If worn, the oil seal and cone should be replaced.

e. Installation.

(1) There is a plastic coating on the outside diameter of the oil seal. Do not remove this coating.

(2) Apply grease to the sealing lip, then position the seal in front cover with the lip of the seal pointed toward the inner face of the cover.

NOTE

The vibration damper inner cone must be removed before installing the oil seal.

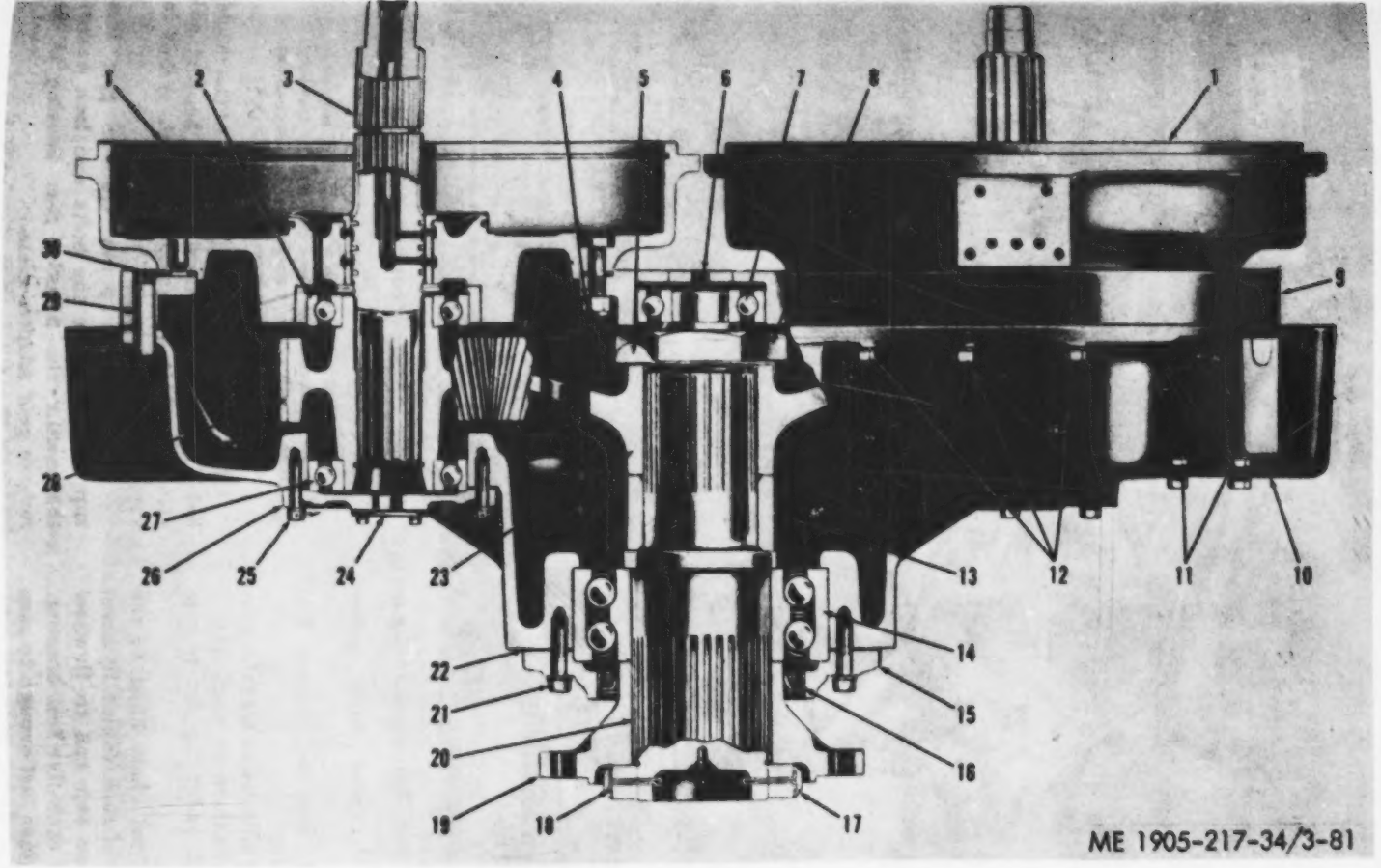
(3) Drive the seal into the front cover with installer J 9783.

(4) Reinstall vibration dampers and crankshaft pulley in reverse order of removal, including inner and outer cones.

(5) Tighten the crankshaft pulley retaining bolt to 290-310 ft-lb torque.

3-23. Transfer Gear Assembly

a. General. The hydraulic marine transfer gear is illustrated in figure 3-81. Power developed by the two engines is delivered through the hydraulic marine gear system to the power drive gear (28), thence to the power driven gear (23) power driven shaft (20). Power drive gear (28) is internally splined to receive the reverse gear drive shaft (3) and is mounted on two ball bearings. The power drive gear bearing (front) (2) is carried in the reverse gear housing (1) power drive gear bearing (rear) (27) is carried in the transfer gear housing (10).



1. Reverse gear housing
2. Power drive gear bearing (front)
3. Reverse gear drive shaft
4. Reverse gear housing to adapter plate nut
5. Driven gear lock washer
6. Driven shaft cover plug
7. Driven shaft pilot ball bearing
8. Driven gear lock nut
9. Reverse gear adapter plate
10. Transfer gear housing
11. Gear housing to adapter plate bolt
12. Gear housing to adapter plate bolt
13. Driven gear spacer
14. Driven shaft ball bearing
15. Driven shaft bearing retainer
16. Driven shaft bearing retainer oil seal
17. Drive flange retaining nut
18. Cotter pin
19. Driven shaft drive flange
20. Power driven shaft
21. Bearing retainer bolt
22. Bearing retainer gasket
23. Power driven gear
24. Special cover
25. Cover bolt
26. Drive shaft cover
27. Power drive gear bearing (rear)
28. Power drive gear
29. Dowel pin
30. Gear housing to adapter plate gasket

Figure 3-81. Power transfer gear assembly (HM marine).

b. Removal.

(1) Drain oil from transfer gear and flywheel housings.

(2) Disconnect the two transfer gear housing to reverse gear housing oil tubes (fig. 3-82).

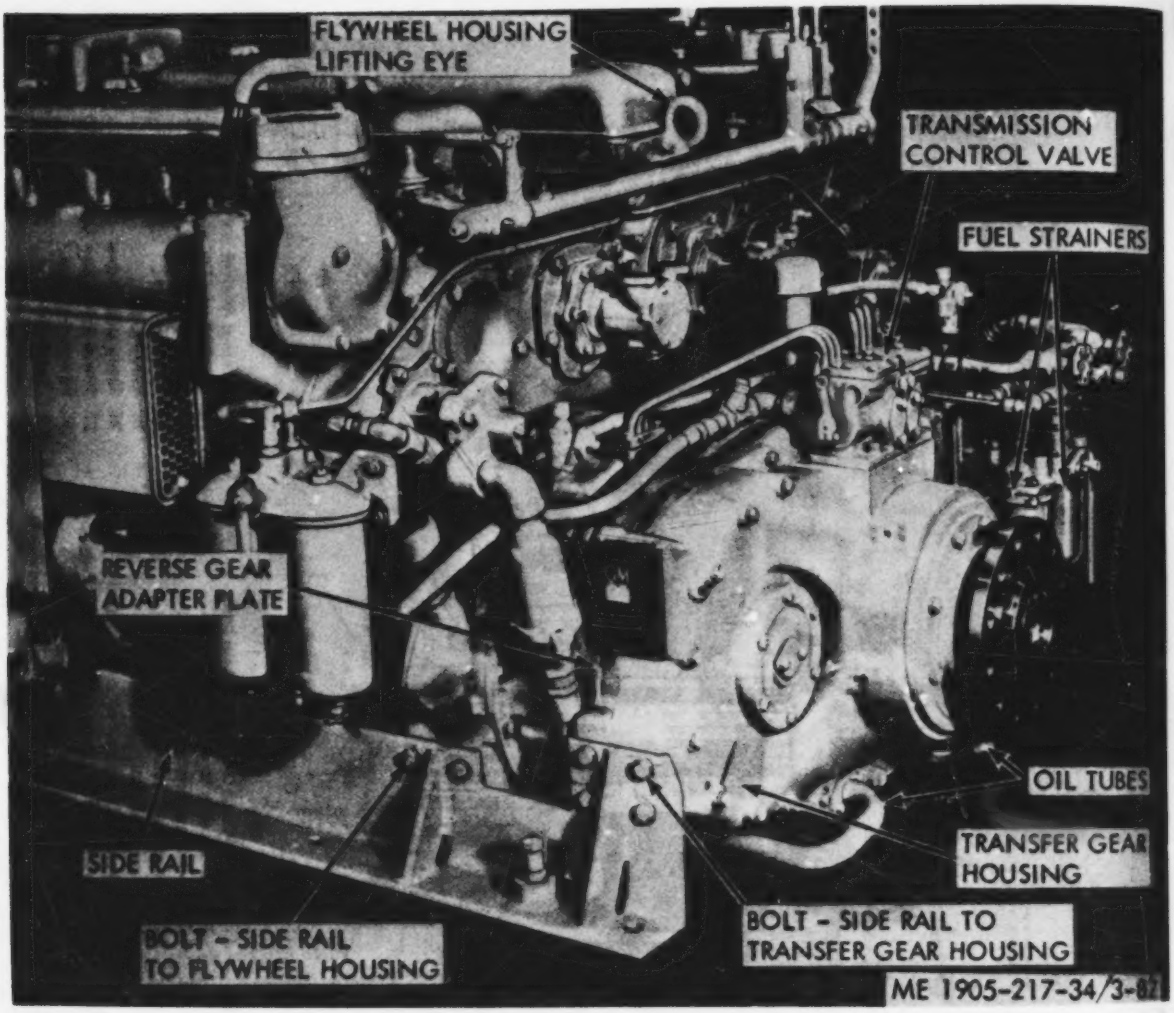


Figure 3-82. Transfer gear housing and flywheel housing, removal and installation.

(3) Remove control valve from power transfer gear housing.

(4) Disconnect fuel lines and remove fuel strainer mounting bracket.

(5) Remove the four side rail to transfer gear housing bolts and lock washers on each side.

(6) Loosen the front motor support to side rail bolts.

(7) Attach a sling and chain hoist to the lifter bracket at the tip of each engine flywheel housing. Remove the two side rail to flywheel housing bolts at side of each flywheel housing. Raise the rear end of engines just enough to ease load of transfer gear from the engine side rails; then, place wood blocks beneath each flywheel housing to support engines.

NOTE

When blocking is in place and load of engines is resting thereon, the space between the mounting boss at each side of transfer gear housing and end of side rails should be approximately 1/8 inch.

(8) Thread an eyebolt into one of the tapped holes provided at each side of gear housing, and attach a chain from hoist to each eyebolt to support transfer gear.

(9) With the power transfer gear thus supported, remove the bolts and lock washers that secure the transfer gear housing to the reverse gear adapter plate.

(10) Start four 3/8 inch-16 bolts into the tapped holes provided in the bolting flange of the gear housing, tighten bolts evenly and crowd

transfer gear away from adapter plate and off dowel pins. Lift transfer gear assembly away from unit.

c. Disassembly.

(1) Support the power transfer gear assembly on suitable wood blocks with the power driven shaft in a horizontal position.

(2) Wedge a clean cloth between the gear teeth to prevent them from turning; then, using a gear puller, remove the driven shaft pilot ball bearing (7, fig. 3-81).

(3) Loosen the power driven gear lock nut (8) and drive flange lock nut (17) as follows:

(a) Straighten ears on lock washer (5) and remove cotter pins (18) from drive flange retaining nut.

(b) Wedge a clean cloth between the gear teeth to prevent the power driven shaft from turning.

(c) Place wrench J 4385-01 over the driven gear lock nut. Then, attach a torque multiplier wrench to wrench J 4385-01 with the end of handle resting on the floor.

(d) Insert a spare reverse gear shaft in each power drive gear. Place a supporting member, with two 2 inch holes having centers 19-1/8 inches apart, and a 1 inch hole centered between the two 2 inch holes, over the splined end of the two drive shafts and push it against the torque multiplier wrench, as shown in figure 3-83, to prevent the drive gears from spreading.

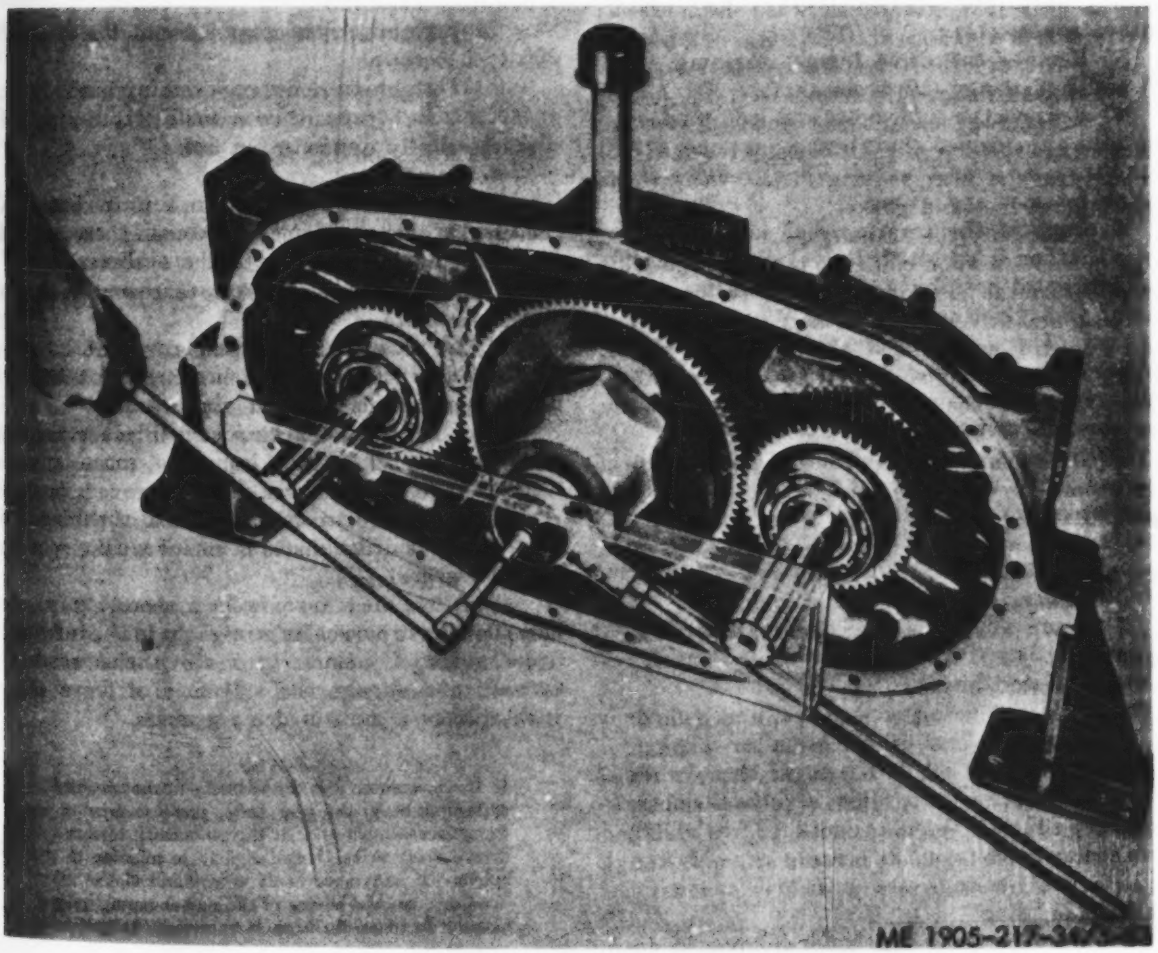


Figure 3-83. Removing lock nut from power driven shaft.

(e) Insert a ½ inch square drive short extension through the 1 inch hole in the supporting wrench; then, attach a flex handle to the short extension. With the transfer gear housing held in a fixed position and a clean cloth between the gear teeth, loosen the driven gear lock nut by turning the nut counterclockwise.

(f) Loosen the drive flange retaining nut (17, fig. 3-81) in the same manner as outlined above, using wrench J 4384-01.

CAUTION

Do not attempt to loosen or tighten the driven gear or drive flange retaining nuts by using a hammer with drift or chisel. Damage to the nuts will occur. Also, the proper torque cannot be obtained when tightening the nuts in this manner.

(4) Remove drive shaft covers (26).

(5) Lift both power drive gears (28) with front bearings (2) and rear bearings (27) out forward face of transfer gear housing. If bearing sticks in housing, use a wood block on outer race and drive from position.

(6) Remove the power driven gear locknut (8) and lock washer (5) from shaft; then, slide the driven gear (23) straight forward from shaft. Remove spacer (13).

(7) Remove the drive flange retaining nut (17) and pull flange (19) from shaft.

(8) Remove the eight bolts and lock washers that secure the driven shaft bearing retainer (15) to the transfer gear housing. Then, remove the bearing retainer and gasket.

(9) Support the transfer gear housing and driven shaft on wood blocks to maintain the shaft in a horizontal position. With the transfer gear housing and driven shaft suitably supported, tap the forward end of the shaft with a plastic hammer to free the shaft and bearing assembly. Then, remove the shaft and bearing assembly from the gear housing.

(10 Support shaft and bearing assembly in an arbor press, with forward face of bearing on split plates, and press shaft from bearing.

(11) Use a press to remove bearings from drive gears (28).

d. Cleaning, Inspection and Repair.

(1) Wash all power transfer gear parts in solvent, (FED. SPEC. PD-680) and blow dry with compressed air.

(2) Inspect bearing races, cups, and balls or rollers for indications of corrosion or pitting. Apply light engine oil to bearings; then, while holding inner race from turning, revolve the outer race or cup slowly by hand to check for free rolling of the balls or rollers on the races or cups. Rough spots in the bearings are sufficient cause for rejection.

(3) Examine teeth of drive and driven gears for wear, scoring or for a chipped or nicked condition. Gears may show considerable wear and still be usable. If gears are worn excessively or chipped and nicked and cannot be cleaned up, they must be replaced.

(4) Examine splines in gear hubs, drive flange and on shafts for wear and peening. If wear and peening is excessive replace shafts, gears and drive flange.

(5) Examine threads on the drive and driven shaft for damage. If threads are severly damaged and cannot be cleaned up, replace the shaft.

(6) Examine oil seals, and if lip of oil seal is nicked, rough, or charred so that a perfect seal will be impossible, replace the oil seals.

(7) Remove all traces of old gaskets before installing the new gaskets.

e. Reassembly.

(1) Refer to figure 3-81 and reassemble the transfer gear in reverse order of disassembly.

(2) Use a press and split support plates to assemble bearings to gears and shaft. Use a thin coat of lubri-plate on bearing race surfaces to facilitate assembly.

(3) Tighten driven gear locknut (8) to 250-300 ft-lb torque.

(4) Tighten drive flange retaining nut (17) to 450-750 ft-lb torque; then install cotter pins in diametrically opposite pin holes.

f. Installation.

(1) Thread an eyebolt into tapped hole at each side of the transfer gear housing, then attach a chain hoist and sling to the eyebolts.

(2) Affix a new gasket to the rear face of adapter plate.

(3) Lubricate the splines of both drive shafts, the driven shaft pilot bearing and the two drive gear bearings with engine oil.

(4) With the blocking still in place beneath the two engine flywheel housings, same as when the transfer gear assembly was removed, position the gear assembly directly in back of the adapter plate with the drive shafts in line with the center of drive gears.

(5) Move the transfer gear assembly forward and pilot the drive shafts straight into the hubs of drive gears. Continue to move the assembly forward and engage the splines of drive shafts with splines in hub of drive gears.

NOTE

If the splines on the drive shafts do not readily engage those in the gear hubs, press forward on the gear assembly and, at the same time, turn the driven shaft drive flange slightly to aline to the splines. If one drive shaft enters and the other does not, bar the engine of the non-engaging gear over by hand until the shaft enters the splines in gear hub.

(6) With the drive shafts entered into the hubs of drive gears, continue to push the assembly forward and enter the driven shaft pilot bearing and the drive gear bearings straight into

bearing bores in the adapter plate. Push the assembly forward over the dowel pins and against the adapter plate gasket.

(7) Install the gear housing to the adapter plate. Tighten the bolts to 30-35 ft-lb torque.

(8) Remove the sling, chain hoist and eyebolts from transfer gear housing.

(9) Attach a sling and chain hoist to the lifting bracket at the top of each engine flywheel housing. Lift the rear of the engines just enough to permit the removal of the blocking from beneath the flywheel housing.

(10 Lower the unit so it rests on the side rails. Aline the bolt holes in the side rail with the bolt holes in the flywheel and transfer gear housings. Then, install the two side rails to the flywheel housing bolts with lock washers on each engine, and the four side rails to gear housing bolts with lock washers at each side of the gear housing.

(11) Tighten the side rail to the flywheel housing and gear housing bolts to 71-75 ft-lb torque.

(12) Tighten the front support bracket to side rail bolt nuts to 83-93 ft-lb torque.

3-24. Crankshaft Rear Oil Seal

a. Removal.

(1) Remove the transfer gear assembly (para 3-23).

(2) Remove flywheel housing (para 3-23).

(3) Support the flywheel housing on its rear face on wood blocks.

(4) Drive the oil seal out and clean the seal bore in the flywheel housing.

b. Inspection and Repair.

(1) Inspect the seal for defects and signs of deterioration.

(2) Replace a defective rear oil seal.

c. Installation.

(1) Support the inner face of the flywheel housing on a flat surface.

CAUTION

There is a plastic coating on the outside diameter of the oil seal. Do not remove this coating.

(2) Position the new seal with the lip turned toward the inner face of the housing.

(3) Drive the seal into the housing with installer J 9727 and handle J 3154-1 until it is seated against the shoulder in the housing bore.

CAUTION

Do not attempt to install this seal with other than prescribed tools since improper installation may allow leaks or damage to crankshaft.

3-25. Main Bearing Caps and Shells

a. Removal. (Crankshaft in Place)

(1) Drain cooling and lubricating systems (TM 55-1905-217-12, para 3-2).

(2) Remove oil pump (para 3-11).

(3) Remove main bearing caps (fig. 3-84)

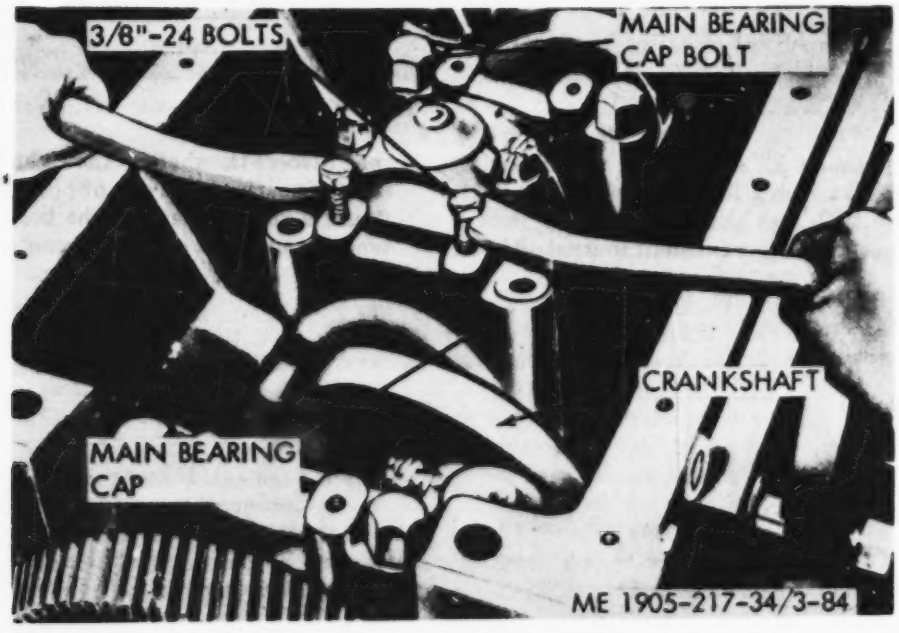


Figure 3-84. Main bearing cap, removal.

(4) Two-piece thrust washers (fig. 3-85) are used each side of the rear main bearing. The lower halves of these washers will be removed when removing the rear main bearing cap. The removal of bearing cap by pushing one end of washer with a small rod, thus forcing washer around and out on opposite side of bearing.

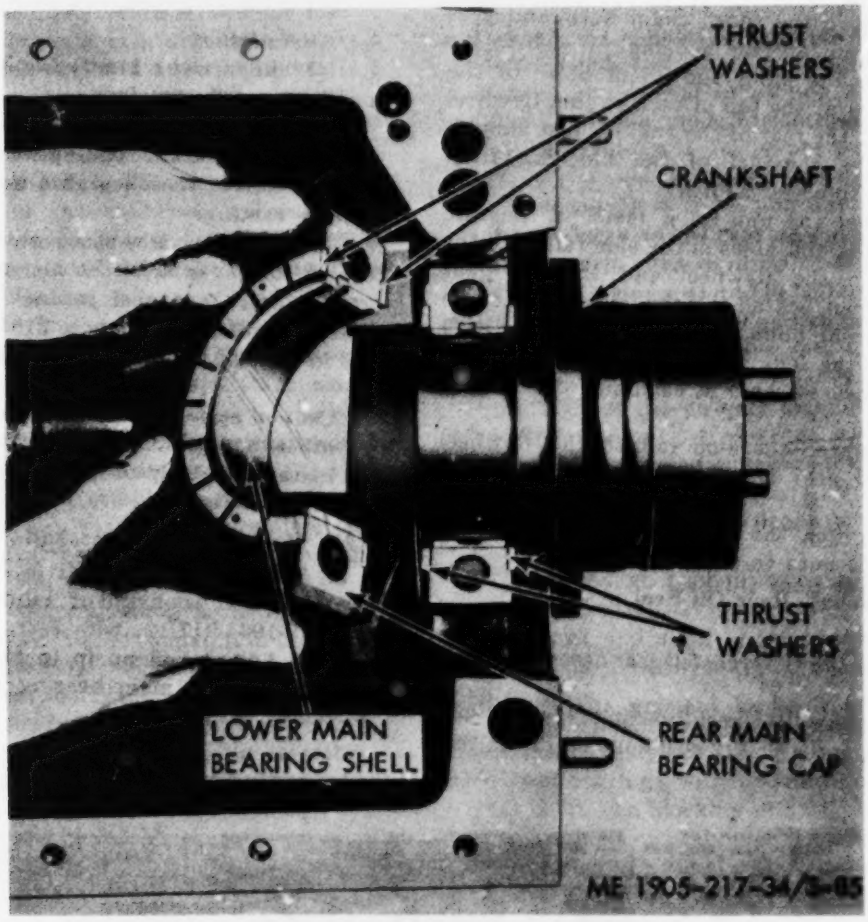


Figure 3-85. Rear main bearing thrust washer and mounting.

(5) To remove all except rear main bearing shell, insert a ¼ inch x 1 inch bolt with a ½ inch diameter by 1/16 inch thick head (made from a standard bolt) into the crankshaft journal oil hole, then revolve the shaft to the right (clockwise) and roll the bearing shell out of position, as shown in figure 3-86. The head of the bolt should not extend beyond the outside diameter of the shell.

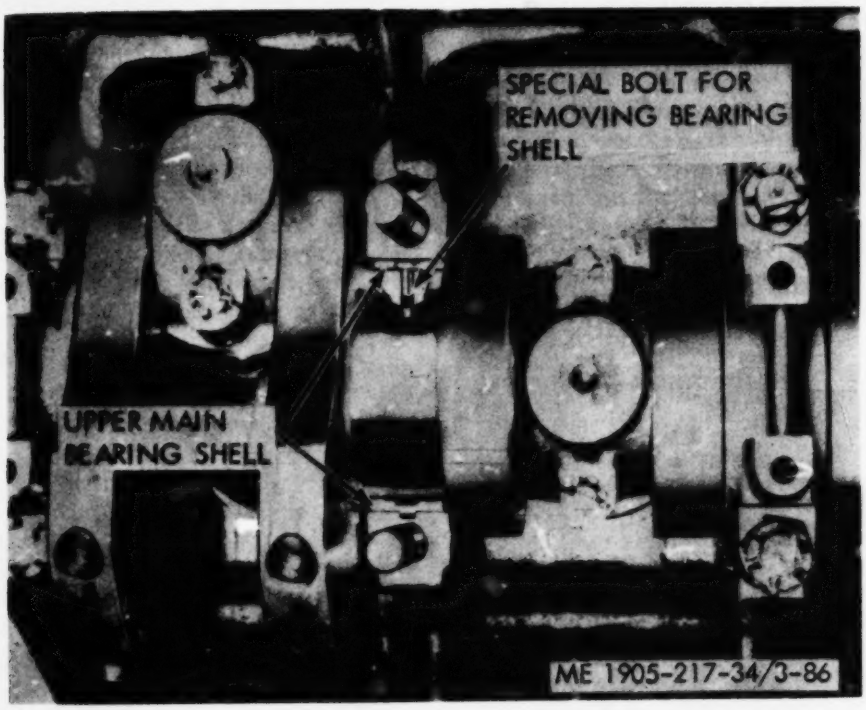


Figure 3-86. Main bearing upper shell, removal (except rear main) crankshaft in place.

(6) Remove rear main bearing upper shell by riving on the edge of the bearing shell with a mall curved rod, at the same time revolving the crankshaft, thus rolling the shell from its position, as shown in figure 3-87.

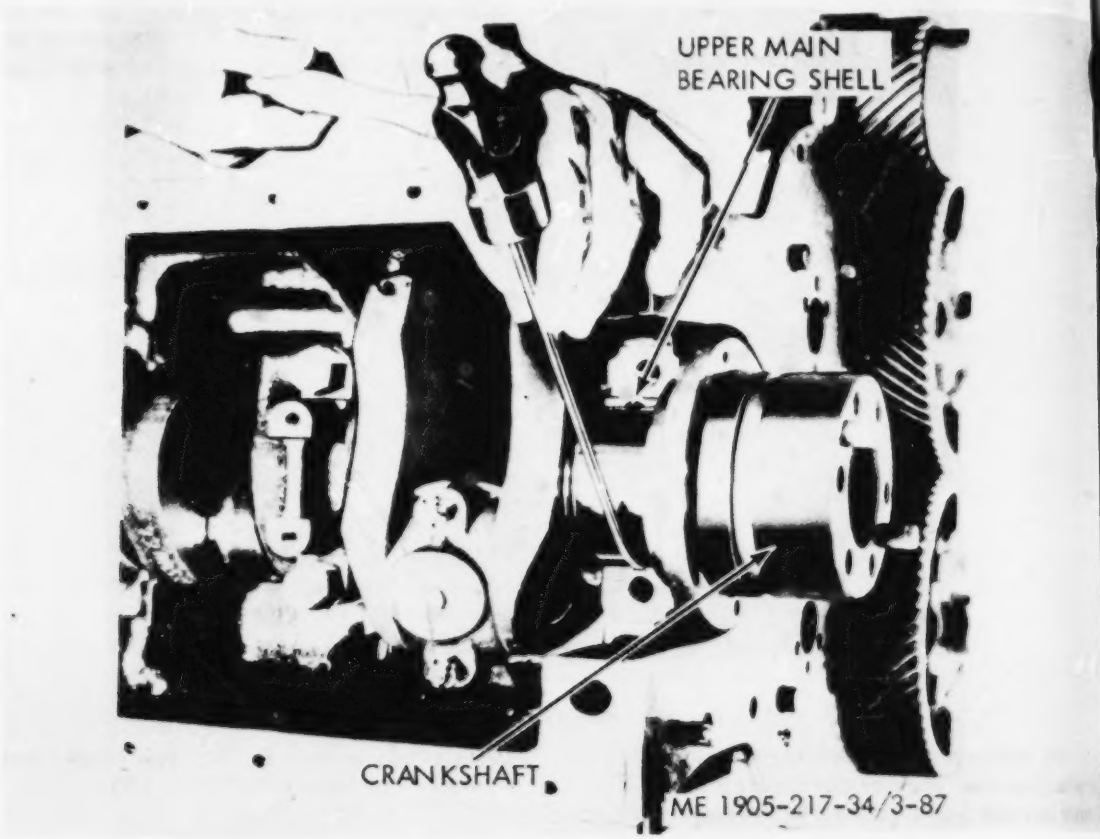


Figure 3-87. Rear main bearing upper shell, removal—crankshaft in place.

NOTE

Remove bearing shells one at a time, inspect and reinstall or replace, replacing all shells if only one or more need replacing.

b. Cleaning. Clean the main bearings caps and shells with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly.

c. Inspection and Repair.

(1) Visual inspection, as well as dimensional measurements, should be made to determine whether used bearings are satisfactory for further service or must be replaced.

(2) Bearing failures may result from contamination of oil or loss of oil which results in scratching, scoring or excessive wear. An analysis of the oil may be required to determine if corrosive acid and sulphur is present resulting in acid etching, flaking and pitting. The oil filter elements should be checked. Also, the oil by-pass valve should be check to assure it is operating freely.

(3) After removal, clean the bearing shells and inspect them for scoring, pitting, flaking, chipping, cracking, loss of babbitt or signs of overheating. If any of these defects are present, the bearings must be discarded. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are NOT detrimental to this type of bearing. The lower bearing shells, which carry the load, will normally show signs of distress before the upper shells do.

(4) Inspect the back of the bearing shells for bright spots which indicate they have been moving in their caps or crankcase. If such spots are present, discard the bearings.

(5) The thickness of the bearing shells should be measured at a point 90° from parting line.

(6) Tool J 4757, placed between the shell and a micrometer will give an accurate measurement. The bearing shell thickness will be the total thickness of steel ball in tool and shell, less the diameter of ball. The above is the only practical method for measuring shell thickness unless a special micrometer is available for this purpose.

(7) Minimum thickness of a worn standard n bearing shell is .153 inch and, if any shells thinner than this dimension, all shells must be arded and replaced with new shells. A new ring shell has a thickness of .1548 inch to 53 inch. In addition to this thickness asurement, the clearance between main rings and crankshaft journals should be cked. This clearance may be determined with crankshaft in place by means of a soft plastic asuring strip, which is squeezed between rnal and bearing, or, with the crankshaft noved, by measuring the outside diameter of crankshaft main bearing journals and the ide diameter of the main bearing shells when talled in place with the porper torque. If the arance between any crankshaft main bearing rnal and its bearing shells exceeds .006 inch, bearing shells must be discarded and replaced th new shells. This clearance is .0014 inch to 044 inch when new parts are used.

(8) Bearing shells when in place have .001 ch larger diameter at the parting line than 90° om the parting line.

NOTE

The two shells do not form a true circle when not installed and when measured for inside diameter should be installed in the cylinder block with caps bolted in place (crankshaft removed).

(9) The two halves of the shells have a queeze fit in the main bearing bore, and must be ght when the cap is drawn down. This "crush" ssures a tight, uniform contact between the earing shell and seat. Bearing shells that do not ave sufficient crush will not have uniform seat ontact, as shown by shiny spots on the bearing hell backs, and should be replaced.

(10) When main bearing replacement is ecessary, it is very important that the rankshaft journals be thoroughly inspected efore new replacement bearings are installed. Very often, after prolonged engine operation, a idge is formed on the circumference of the rankshaft journals in line with the journal oil oles. This ridge must not exceed .0002 inch and, f it is not removed before new bearings are installed, then, during engine operation, localized high unit pressures in the center area of the bearing shell will cause pitting of the bearing surface. Bearings that have failed may result in bending fatigue and resultant cracks in the crankshaft.

(11) The crankshaft journals may be inspected for scoring, over-heating or wear without removing the crankshaft. To measure journal diameters, however, removal of the crankshaft is necessary.

(12) The crankshaft thrust washers, located at the rear main bearing consist of two pieces on each side of the bearing cap. Excessive end play from use of an improper flywheel or improper clutch adjustment can be contributory factors to excessive wear on the thrust washers. If the washers have become scored or otherwise damaged, or if the crankshaft end play is excessive, they must be replaced. The specified crankshaft end play, with new thrust washers, is .004 inch to .011 inch. The maximum allowable end play with used washers is .018 inch.

d. Installation (Crankshaft in Place).

(1) Make sure all of the parts are clean. Then apply clean engine oil to the crankshaft journals and install the main bearing shells by reversing the sequence of operations given for removal.

(2) Upper and lower main bearing shells are not alike; the upper shell is grooved and drilled for lubrication—the lower shell is not. Be sure to install the grooved and drilled shells in the cylinder block and the plain shells in the bearing caps. Used bearing shells must be reinstalled on the same journal from which they were moved.

(a) When installing the upper main bearing shells with the crankshaft in place, start the plain end of the shell around the crankshaft journal so that, when the shell is in place, the tank will fit into the groove in the bearing support.

(b) Assemble the crankshaft thrust washers before installing the rear main bearing cap. Clean both halves of each thrust washer carefully, removing any burrs from the washers and the bearing cap—the slightest burr or particle of dirt may decrease the clearance between the washers and the crankshaft beyond specified limits.

(c) Slide the upper halves of the thrust washers in place in the grooves as shown in figure 3-85; then assemble the lower halves over the dowel pins in the bearing cap.

NOTE

Main bearing caps are bored in position and marked 1, 2, 3, etc. They must be replaced in their original positions with the marked side of each cap toward the blower side of the cylinder block.

(d) With the lower bearing shells installed in the bearing caps, lubricate the bolt threads and the bolt head contact areas with SAE 30 engine oil. Install the caps and draw the bolts up snug. Then rap the caps sharply to seat them properly and uniformly tighten the bolts to torque specified in table 4, chapter one. Tighten nuts and bolts to the high side of the torque specification, but do not exceed the limit.

NOTE

If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing caps bolted tight.

(e) Check the crankshaft end play. Refer to table 1-2.

(f) Install the oil pump and pan (paras 3-19, 3-18).

(g) Fill the lubricating and cooling systems TM 55-1905-217-12 (para 4-9 and 4-41).

3-26. Transmission and Flywheel

a. General.

(1) The torquematic marine reverse gear, along with the flywheel assembly, figure 3-88, provides positive clutch engagement or release by moving the control valve lever to forward, neutral, or reverse.

Key to figure 3-88.

1. Reverse gear drive shaft
2. Flywheel ring gear
3. Forward clutch piston
4. Forward clutch drive plate
5. Reverse gear to flywheel housing gasket
6. Reverse clutch plate
7. Reverse clutch piston
8. Bearing
9. Driven gear lock nut
10. Lock washer
11. Spacer
12. Bearing assembly
13. Driven shaft bearing cover
14. Driven shaft bearing cover oil seal
15. Drive flange
16. Drive flange nut
17. Driven shaft
18. Cotter pin
19. Bearing cover bolt
20. Lock washer
21. Bearing cover gasket
22. Driven gear
23. Drive gear bearing assembly
24. Special cover
25. Reverse gear drive shaft cover
26. Drive shaft cover bolt
27. Drive shaft cover gasket
28. Drive gear
29. Transfer gear housing
30. Drive gear bearing assembly
31. Adapter plate dowel pin
32. Transfer gear housing to adapter plate gasket
33. Reverse gear adapter plate
34. Reverse gear to adapter plate gasket
35. Reverse gear housing
36. Reverse ring gear
37. Reverse clutch drive plate
38. Dump valve plug
39. Forward clutch dump valve
40. Dump valve spring
41. Flywheel housing
42. Planetary gear assembly
43. Flywheel pilot bearing
44. Flywheel to crankshaft bolt
45. Flywheel pilot bearing retainer
46. Flywheel
47. Forward clutch plate
48. Emergency engagement bolt
49. Nut
50. Reverse gear to adapter plate bolt

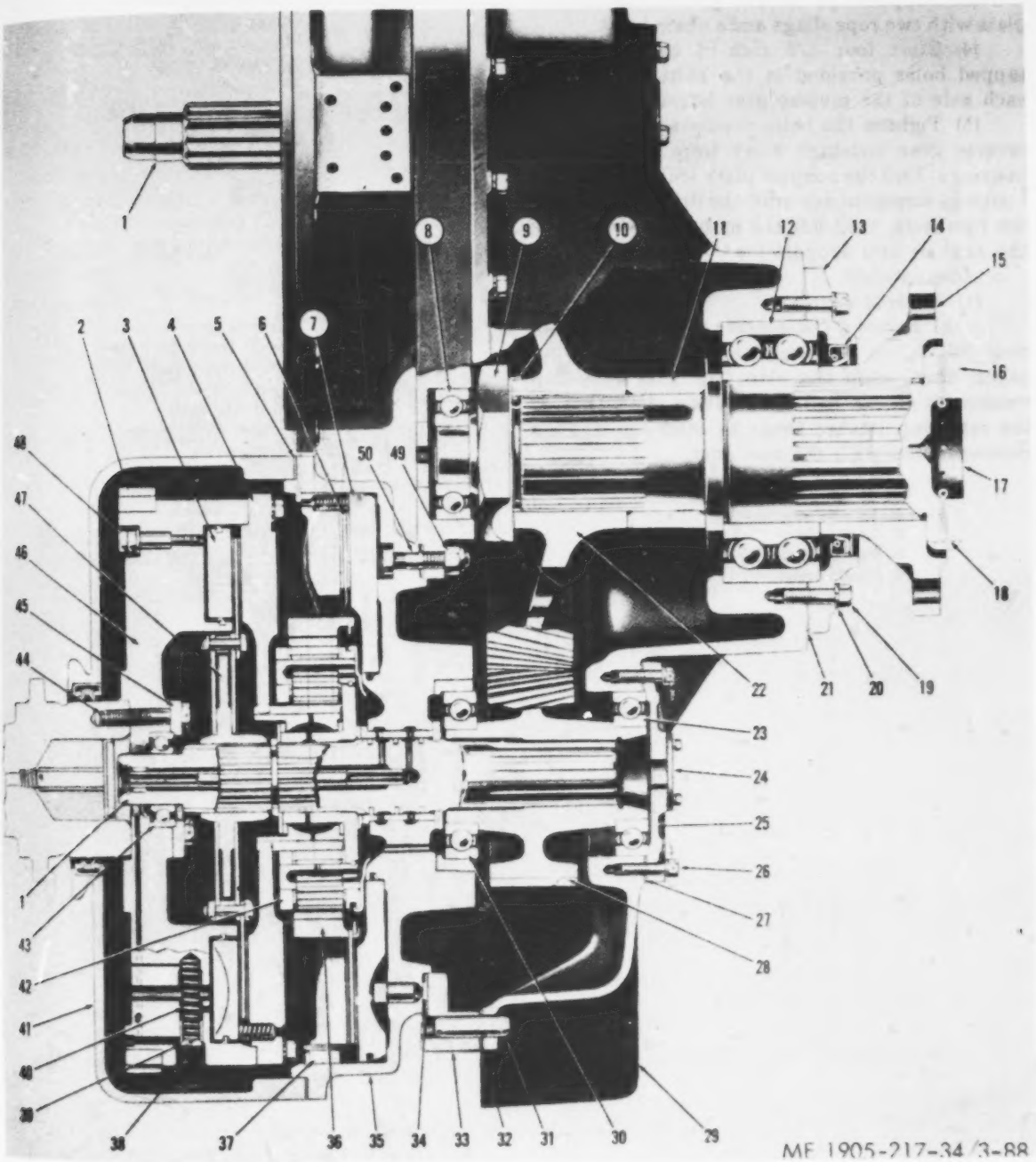


Figure 3-88. Torquematic marine gear and flywheel assembly, cross-section view.

(2) Each marine gear consists of a flywheel and forward drive clutch assembly, and a reverse drive clutch assembly with a through drive shaft. Also each has an oil pump to supply oil under pressure for operating the forward and reverse clutches, a control valve to admit oil to the clutches, an oil strainer, a full-flow oil filter, and an oil cooler.

(3) Power from the engine is transmitted to the through drive shaft by locking the forward or reverse clutch plate between the hydraulically operated piston and drive plate.

b. Removal.

(1) Refer to paragraph 3-23 and remove the power transfer gear assembly.

(2) With the engines still supported, remove the bolts and lock washers securing the reverse gear housings to the engine flywheel housing.

(3) Support the reverse gears and adapter plate with two rope slings and a chain hoist.

(4) Start four 3/8 inch-16 bolts into the tapped holes provided in the bolting flange at each side of the reverse gear housings.

(5) Tighten the bolts evenly and crowd the reverse gear housings away from the flywheel housings. Pull the adapter plate and reverse gear housings straight back until the drive shafts clear the flywheels, then left the assembly away from the engines and support on wood blocks.

c. Disassembly.

(1) Reverse gear

(a) Remove the planetary gear retaining ring (27, figure 3-89) with a pair of snap ring pliers; then, slide the planetary gear retaining washer (3) off the end of the drive shaft (10). If the retaining washer tends to stick, it may be removed later with the sun gear.

Key to figure 3-89.

1. Reverse gear housing
2. Dowel pin
3. Reverse clutch release spring
4. Needle roller
5. Shaft retaining ball
6. Carrier assembly
7. Planetary gear thrust washer
8. Oil transfer sleeve
9. Thrust washer
10. Reverse gear drive shaft
11. Retaining ring
12. Thrust washer
13. Oil seal ring
14. Seal ring
15. Expander
16. Clutch drive pin
17. Reverse clutch piston
18. Expander
19. Seal ring
20. Pin
21. Retaining ring
22. Reverse clutch drive plate
23. Reverse clutch plate
24. Planet gear
25. Planet gear shaft
26. Sun gear thrust washer
27. Retaining ring
28. Retaining ring
29. Oil transfer tube
30. Retaining washer
31. Sun gear
32. Reverse ring gear
33. Retaining ring

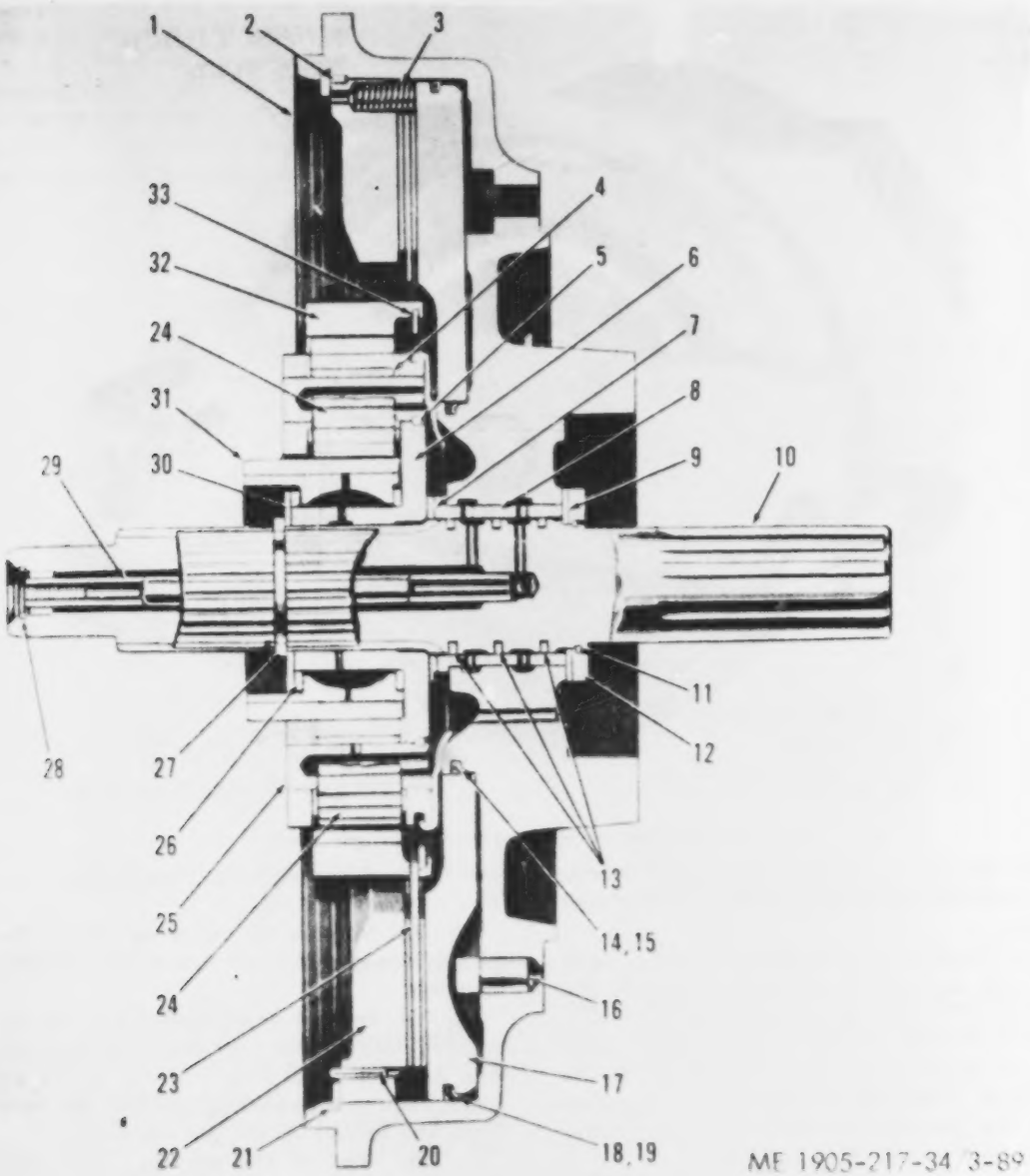


Figure 3-89. Reverse gear assembly, cross-section view.

(b) Remove the reverse sun gear (31), reverse planetary gear assembly and the sun gear thrust washer (26) together from the reverse gear drive shaft. The reverse sun gear and the thrust washer may be removed separately.

(c) Remove the reverse gear thrust washer (7) from the reverse gear drive shaft.

(d) If inspection of the planetary gears reveals nicks, burrs, pitting, overheating, galling or excessive backlash (more than .015 inch) between any two mating gears, the planetary assembly should be replaced with a new planetary assembly.

(e) Tap the three snap ring retaining spring pins (20) into the reverse clutch drive plate (22) with a small punch and hammer, until they clear the edge of the retaining ring (21).

(f) Clamp a board across the face of the reverse gear housing with a 1 inch wood block at each end between the board and the clutch drive plate as shown in figure 3-90. Remove the retaining ring (21, fig. 3-89) from the groove in the housing with a screwdriver.

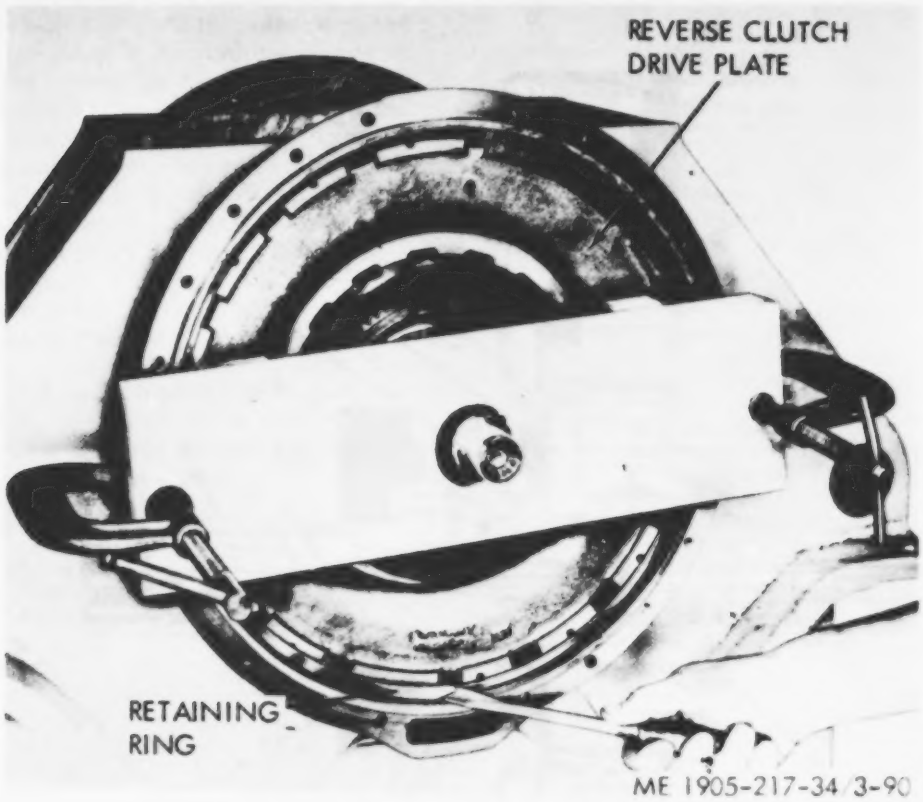


Figure 3-90. Removing retaining ring from reverse gear housing.

(g) Remove the clamps, board and blocks from the reverse gear housing and reverse clutch drive plate.

(h) Thread a piston remover tool J 4746 (T-head bolt) into each of two tapped holes in the forward face of the reverse clutch drive plate (22).

(i) Pull the reverse clutch drive plate straight forward until the drive plate is free in the gear housing. Then, lift the drive plate, together with the ring gear (32) and clutch plate assembly (23) from the reverse gear housing.

(j) Remove the sixteen clutch release springs (3) and the three drive plate dowel pins from the reverse gear housing and reverse clutch drive plate.

(k) Remove the reverse clutch plate retaining ring (33) from the groove in the reverse ring gear with a screwdriver. Lift the clutch plate from the ring gear.

(l) Thread a piston remover Tool J 4746 (T-head bolt) into each of two tapped holes in the forward face of the reverse clutch piston (17).

(m) Place a 2 inch x 4 inch x 2 foot length of wood block over the edge of the reverse gear housing and beneath the cross bar of each remover tool. Push down evenly on the end of the two wood blocks, and break the oil seal (vacuum lock) in back of the piston, thus freeing the piston in the housing.

(n) Remove the two wood blocks. Pull the piston straight forward out of the reverse gear housing.

(o) Insert a small screwdriver beneath the reverse clutch piston seal ring in the gear housing and work the seal ring (14) out of its groove. Then, remove the seal ring and seal ring expander from the groove in the gear housing.

(p) Remove the seal ring and seal ring expander from the reverse clutch piston in the same manner.

(q) Remove the reverse gear housing from the reverse gear adapter plate (33, figure 3-88) as follows:

1. With the reverse gear components removed from the reverse gear housing, remove the reverse gear drive thrust washers and snap ring from the reverse gear housing.

2. Support the reverse gear housings and adapter plate on three wood blocks, with the rear face of the adapter plate facing up.

3. Remove the eleven elastic stop nuts securing the reverse gear housing to the adapter plate.

4. Turn the reverse gear housings and adapter plate over and rest the rear face of the adapter plate on the wood blocks.

5. Tap evenly around the back side of the reverse gear housing with a plastic hammer to loosen the reverse gear housing from the adapter plate. Then, lift the reverse gear housing straight up away from the adapter plate.

(r) With the reverse gear drive shaft removed from the reverse gear housing, unhook the ends of the three oil seal rings. Slide each ring off the forward end of the drive shaft, as shown in figure 3-91.

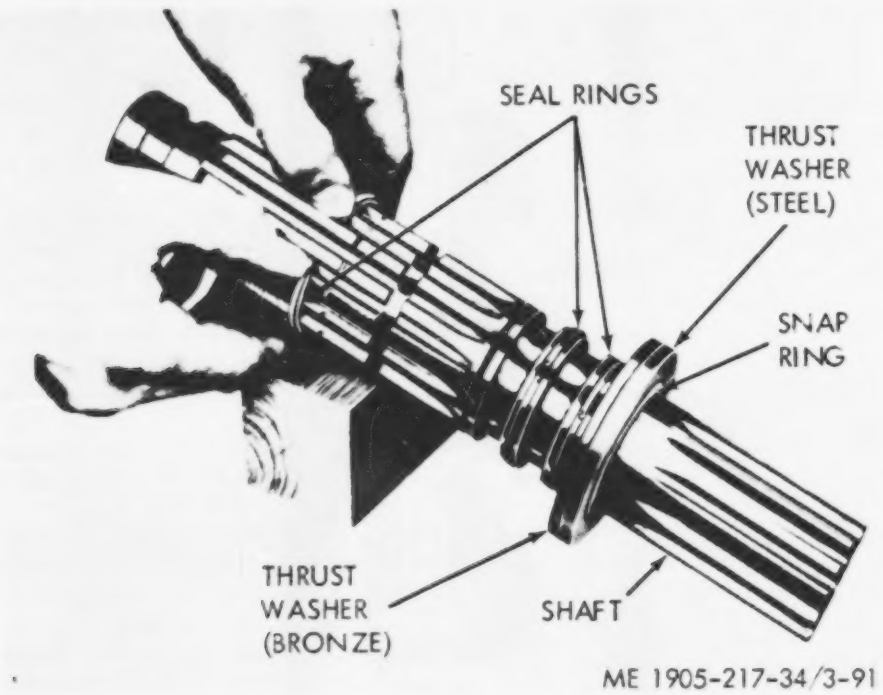


Figure 3-91. Removing oil seal rings from reverse gear drive shaft.

CAUTION

Do not spread the seal rings more than necessary to slip them over the shaft to avoid breakage.

(s) Move the two drive shaft thrust washer forward on the drive shaft, to expose the rear thrust washer snap ring. Remove the snap ring from the drive shaft with a pair of snap ring pliers. Slide the two thrust washers off the end of the drive shaft.

(t) If the oil transfer sleeve (8, figure 3-88) in the reverse gear housing is worn excessively or damaged, it should be removed as outlined below:

1. Support the reverse gear housing on the bed of a hydraulic press. The forward face of the reverse gear housing must be facing down.

2. Place a 2½ inches O.D. brass bar approximately 4 inches long on top of the oil transfer sleeve and under the ram of the press.

3. Bring the ram of the press down on the brass bar and force the oil transfer sleeve out of the gear housing. Catch the oil transfer sleeve and brass bar by hand to prevent them from falling on the floor.

(u) If the reverse clutch drive pins (16, fig. 3-89) in the inner face of the reverse gear housing are damaged or worn excessively, they should be removed as outlined below:

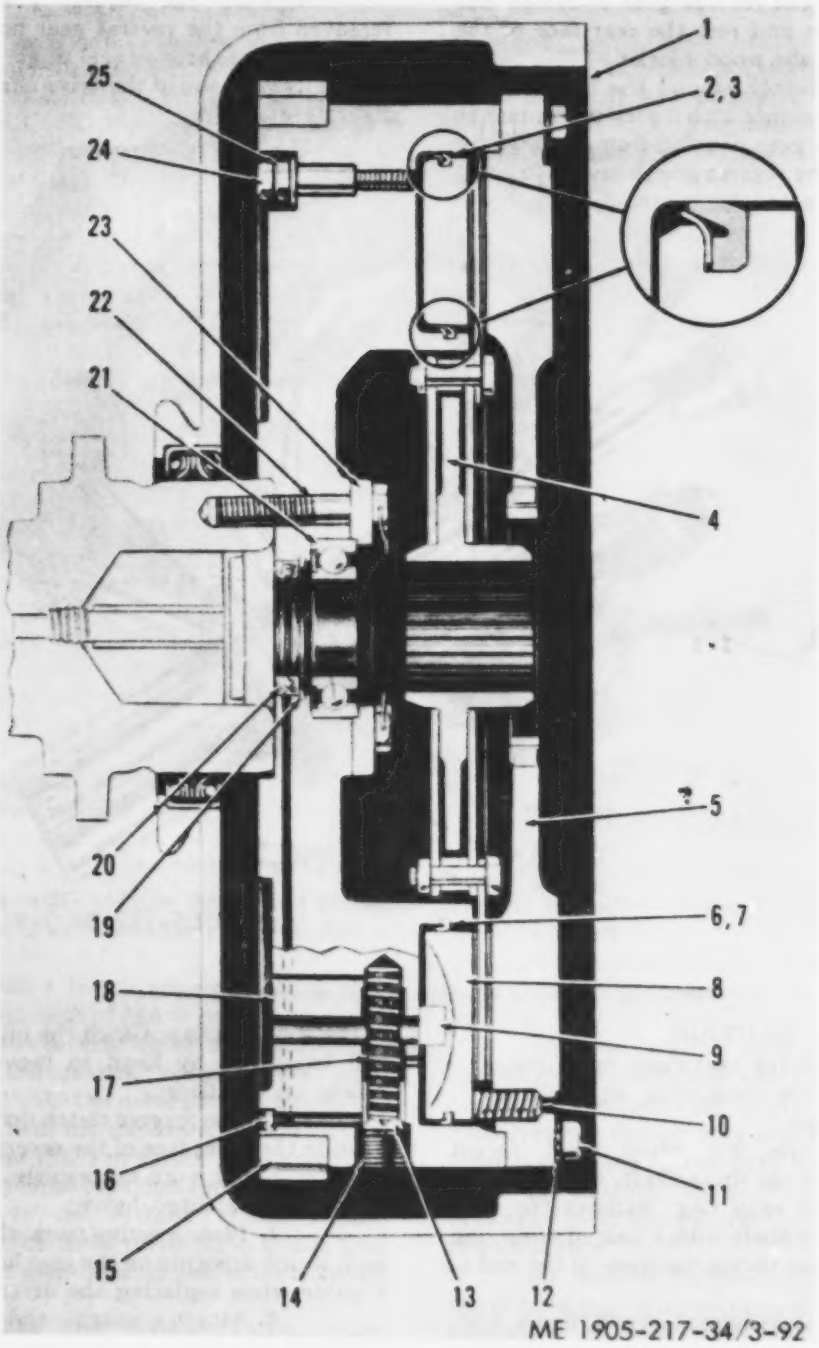
1. Place a scribe mark along one side of each clutch drive pin on the gear housing to use as a guide when replacing the drive pins.

2. Attach a suitable slide hammer and a 5/16 inch-18 adapter to the drive pin. Remove the drive pin with a few sharp blows against the shaft handle with the weight.

3. Remove the two remaining drive pins in the same manner.

(2) Flywheel and Forward Clutch

(a) Remove fourteen of the sixteen bolts (11, fig. 3-92) and lock washers securing the forward clutch drive plate (5) to the flywheel.



1. Flywheel housing
2. Forward clutch piston (outer) seal ring
3. Forward clutch piston seal ring (outer) expander
4. Forward clutch plate
5. Forward clutch drive plate
6. Forward clutch piston (inner) seal ring
7. Forward clutch piston seal ring (inner) expander
8. Forward clutch piston
9. Clutch drive pin
10. Forward clutch release spring
11. Forward clutch drive plate bolt
12. Lock washer
13. Forward clutch dump valve
14. Dump valve plug
15. Ring gear
16. Oil passage plug
17. Dump valve spring
18. Flywheel
19. Pilot bearing oil seal retaining ring
20. Pilot bearing oil seal
21. Flywheel pilot bearing
22. Flywheel to crankshaft bolt
23. Flywheel pilot bearing retainer
24. Emergency engagement bolt
25. Emergency engagement jam nut

Figure 3-92. Flywheel and forward clutch, cross-section view.

(b) Support the forward clutch drive plate with lifting hook and a chain hoist to prevent the plate from falling.

(c) Remove the two remaining bolts (11) and lock washers, and lift the drive plate away from the flywheel. Use care when removing the plate not to lose the sixteen clutch release springs (10) in the forward face of the drive plate.

(d) Remove the sixteen clutch release springs from the clutch drive plate. Also, remove the forward clutch plate assembly (4) from the flywheel.

(e) Loosen the six self-locking bolts (22) securing the flywheel to the engine crankshaft. Then, remove the bolts and pilot bearing retainer (23).

(f) Attach flywheel lifting tool to the flywheel with two 7/16 inch-14 bolts of suitable length. Then, attach a chain hoist to the lifting tool to support the flywheel.

(g) Move the upper end of the tool in and out to loosen the flywheel, then withdraw the flywheel from the crankshaft and the flywheel housing.

(h) Support the flywheel on two wood blocks, with the ring gear side of the flywheel facing up.

(i) Remove the three emergency engagement bolts (24) with jam nuts from the flywheel.

NOTE

On the flywheel assembly that incorporates six emergency engagement bolts, it is only necessary to remove three of the bolts (every other one).

(j) Stand the flywheel up on edge with a thin strip of wood under the rear edge to prevent it from tipping over.

(k) Thread a ½ inch-13 x 2¼ inch bolt with long thread into each of the emergency engagement bolt holes until they contact the forward clutch piston (8).

(l) While supporting the flywheel and piston, continue to turn the bolts in EVENLY until the peripher of the piston with seal ring is free of the flywheel. Then, lift the piston away from the flywheel.

CAUTION

The piston must be forced EVENLY out of the flywheel to prevent damage occurring to the seal rings in the piston and the flywheel.

(m) Remove the three ½ inch-13 x 2¼ inch bolts from the flywheel that were used to remove the piston from the flywheel. Then support the flywheel on two wood blocks, with the ring gear side of the flywheel facing down.

(n) Remove the pilot bearing from the flywheel with remover adapter J 5901-2 and slide hammer.

(o) Inspect the lip of the drive shaft pilot bearing oil seal (20) for nicks, roughness and charring. If inspection reveals the oil seal is unfit for further use, remove it as follows:

1. Remove the oil seal retaining ring (19) from the back side of the oil seal in the flywheel, with a pair of small-nose pliers.

2. Place the oil seal remover J 4700 on top of the oil seal. Then drive the oil seal out of the flywheel with a hammer.

(p) Remove the special plug (14) in the periphery of the flywheel retaining the forward clutch dump valve and spring in the flywheel. Then, remove the dump valve and spring from the flywheel.

(q) Insert a small screw driver beneath the forward clutch piston inner seal ring (6) in the flywheel and work the seal ring out of its groove. Then, remove the seal ring and seal ring expander (7) from the groove in the flywheel.

(r) Remove the outer seal ring and the seal ring expander from the forward clutch piston in the same manner as described in step (17).

(s) If the forward clutch piston drive pins (9) in the inner face of the flywheel are damaged or worn excessively, they should be removed as outlined below:

1. Place a scribe mark along one side of each clutch drive pin on the flywheel to use as a guide when replacing the drive pins.

2. Remove the drive pins with a drift and hammer through the holes provided in the forward face.

d. Cleaning, Inspection, and Repair.

(1) Wash all of the reverse gear and flywheel parts in cleaning solvent (FED. SPEC. PD-680), blow dry with compressed air, then inspect.

(2) If the splines on the drive shaft are worn or peened excessively, they should be replaced.

(3) If the facings of the forward and reverse clutch plates show signs of over-heating or worn excessively, they should be replaced.

(4) If the splines in the hub of the forward clutch plate are excessively worn or peened, it should be replaced.

(5) If the clutch facing (friction) surface of the reverse and forward pistons and their respective drive plates are scratched, worn or show signs of overheating, they should be replaced.

(6) If the slots for the drive pins in the back side of the pistons show excessive wear, the pistons and drive pins should be replaced.

(7) Examine the forward and reverse clutch piston seal rings for cuts and scratches. If cuts, scratches or any deformity is found on the seal rings, they must be replaced.

(8) If the forward clutch piston type dump

valve is scored or pitted and cannot be cleaned up with crocus cloth, it must be replaced. If the dump valve bore in the flywheel is scored or brinelled and cannot be cleaned up, replace the flywheel.

(9) If the reverse gear drive shaft thrust washers are worn or scored excessively, they must be replaced.

(10) If the reverse gear drive shaft oil seal rings are worn or scored excessively, they must be replaced.

(11) If the inside diameter of the oil transfer sleeve is worn or scored excessively, it must be replaced.

(12) Inspect the drive shaft pilot bearing for indication of corrosion and pitting. Lubricate the bearing with light engine oil; then, while holding the bearing inner race from turning, revolve the outer race slowly by hand to check for rough spots in the bearing. Rough spots in the bearing is sufficient cause for rejection.

(13) Inspect the planetary gear assembly. A maximum backlash of .015 inch is permitted between any two gears within the planetary assembly. Replace assembly if backlash is excessive.

(14) Clean all oil passages in the flywheel, reverse gear housing and drive shaft with compressed air.

(15) When a major overhaul of the torqmatic marine gear is being performed, all of the flexible oil tubes attached to the maring gear oil pump, oil filter, oil strainer, control valve and oil cooler must be removed, cleaned and blown out with compressed air. Also, remove and clean the marine gear oil cooler element.

e. Reassembly.

(1) Flywheel and forward clutch.

(a) If removed, install the oil passage plugs (16, fig. 3-92) in the flywheel. Proper position of the plugs is flush with or slightly below the outer surface of the flywheel.

(b) Support the flywheel on wood blocks with the forward (ring gear) side up.

(c) Install the pilot bearing oil seal retaining ring (19) in the ring groove in the flywheel with a pair of small-nose pliers.

(d) Install the pilot bearing oil seal (20) in the flywheel as follows:

1. Apply a thin coat of sealing compound to the outside diameter of the oil seal casing.

2. Place the oil seal on the pilot oil seal replacer J 4700 with the lip of the seal facing the flange of the tool.

NOTE

The lip of the oil seal must face the crankshaft side of the flywheel.

3. Start the oil seal straight into the bore of the flywheel, and tap it down against the oil seal retaining ring.

CAUTION

When installing the oil seal, use care not to drive too hard against oil seal retaining ring or damage to the thin flange of the retaining ring groove may occur.

(e) Install the emergency engagement bolts (24) with a jam nut on each bolt, in the tapped holes in the forward face of the flywheel. Tighten the bolts securely against the jam nuts.

NOTE

The jam nuts serve as spacers to prevent the emergency engagement bolts from contacting the forward piston during normal operation.

(f) If removed, install the forward clutch piston drive pins (9) in the flywheel as follows:

1. Support the flywheel on wood blocks with the forward (ring gear) side down.

2. Note the scribe marks placed on the flywheel at the time the old pins were removed. Start a drive pin in each of the drive pin holes in the rear face of the flywheel, with the square head of the drive pin in line with the scribe mark.

3. With a soft (lead) hammer, drive the pins straight into the flywheel until the head of the pins contact the surface of the flywheel.

NOTE

The sides of the pins must aline with the scribe marks. If a pin has twisted slightly out of line when installing, line it up with a wrench.

4. Place the forward clutch piston (8) without seal ring-down over the drive pins to assure the heads of the pins will engage the slots in the piston without binding. Then, remove the piston from the flywheel.

(g) Lubricate the pilot bearing (21) with clean engine oil. Start the bearing straight into the bore of the flywheel with the shielded side of the bearing facing the oil seal. Tap the bearing down in the flywheel with a clean wood block and hammer.

(h) Place the seal ring expander (7) in the seal ring groove of the flywheel; then, starting at the approximate center of the expander, feed the thick lip of the seal ring into the groove next to the expander with the narrow lip of the seal ring pointed down into the flywheel.

(i) Lubricate the outside of the forward clutch dump valve (13) with engine oil. Place the dump valve spring inside the dump valve. Insert the spring and valve into the valve opening in the flywheel and install the retaining plug. Tighten the plug until it is flush with the periphery of the flywheel. Then, stake the plug at two places with a center punch.

(j) Place the forward clutch piston (8) on a bench with the drive pin (9) slots in side of piston facing up. Place the seal ring expander (3) in the seal ring groove at the periphery of the piston; then, starting at the approximate center of the expander, feed the thick lip of the seal ring into the groove next to the expander with the narrow lip of the seal ring facing the side of the piston having the drive pin slots.

(k) Install the forward clutch piston (8) in the flywheel as follows:

1. Apply a light grade of engine oil to the seal ring in the piston, and in the flywheel.

2. With the flywheel resting on the bench (ring gear side down), place the piston into the flywheel with the slots in the under side of the piston in alignment with the drive pins in the flywheel.

3. Lower the piston into the flywheel, and press the piston uniformly down over the drive pins, using extreme care not to dislodge the seal rings from their grooves.

(l) Insert the end of a .006 inch feeler gage between the lip of the outer seal ring and the flywheel.

CAUTION

The end and edges of the feeler gage must be smooth and free of nicks or burrs.

1. Carefully slide the feeler gage around between the outer seal ring and the flywheel and check for any bind on the feeler gage. Then, check the clearance between the inner seal ring and flywheel. If a bind occurs, the lip of the seal ring may have turned up or the piston may not be centrally located.

2. If the lip of either of the seal rings has turned up, remove the piston and install a new seal ring. Recheck the clearance.

3. If the piston is not centered, tap the face of the piston (opposite the bind) lightly with a plastic hammer. If the bind still exists, remove the piston and turn 120° or 240°, reinstall the piston and again check clearance.

(m) The flywheel to crankshaft attaching bolts are not accessible after the forward clutch plate and drive plate have been assembled to the flywheel; therefore, attach the flywheel to the crankshaft at this stage of the assembly.

1. Attach flywheel lifting tool to the flywheel with two bolts of suitable length. Then, with the use of a chain hoist, position the flywheel in the flywheel housing and in line with the crankshaft.

NOTE

Since one flywheel-to-crankshaft bolt hole is offset, the flywheel can be installed in one position only.

2. Rotate the flywheel until the dowel pin holes in the flywheel align with the dowels in the crankshaft. Then, pilot the flywheel over the dowels. Install two of the flywheel-to-crankshaft bolts and tighten them sufficiently to draw the flywheel against the end of the crankshaft.

3. Remove the flywheel lifting tool and the two bolts that were used to draw the flywheel up against the crankshaft.

4. Place the pilot bearing retainer (23) up against the flywheel with the bolt holes in alinement. Then, install the six flywheel-to-crankshaft bolts. Tighten the bolts to 150-160 ft-lb torque.

5. If the flywheel attaching bolts have drilled heads, lock each pair of bolts together with lockwire.

(n) Place the forward clutch plate (4) in the flywheel next to the piston with the spring loaded side of the plate inside the flywheel.

NOTE

Immerse the clutch plate in a very light grade of engine oil for approximately one-half hour before assembly.

(o) Thread a 3/8 inch-16 x 3 inch pilot stud into each of two diametrically opposite bolt holes in the rear of the flywheel.

(p) Apply a small amount of cup grease on one end of each forward clutch release spring (10). Then, insert the greased end of the springs into the sixteen holes in the forward face of the drive plate (5).

(q) Attach the forward clutch drive plate (5) to the flywheel as follows:

1. Support the drive plate with lifting hook and a chain hoist and position the drive plate over the pilot studs in the flywheel housing. Remove the chain hoist and lifting hook.

2. Carefully slide the drive plate forward until the release springs in the lower portion of drive plate contact the clutch plate (4).

3. Raise the clutch plate just enough to permit the release springs to pass under it, then push the drive plate forward until the springs contact the piston (8).

4. Install fourteen of the drive plate to flywheel attaching bolts and lock washer. Remove the two pilot studs and install the two remaining bolts and lock washers. Tighten the bolts uniformly to 30-35 ft-lb torque.

NOTE

Make sure the clutch plate remains free between the piston and drive plate when tightening the bolts.

(2) Reverse Gear

(a) If removed, install the reverse clutch

drive pins in the reverse gear housing (1, figure 3-89) as follows:

1. Support the reverse gear housing on wood blocks, with the rear face of the housing down.

2. Note the scribe marks placed on the gear housing at the time the old pins (16) were removed. Start a new drive pin (16) in each of the drive pin holes in the forward face of the gear housing, with the square head of the drive pin in line with the scribe mark.

3. With a soft (lead) hammer, drive the pins straight into the gear housing until the head of the pins contact the surface of the gear housing.

NOTE

The sides of the pins must aline with the scribe marks. If a pin has twisted slightly out of line when installing, line it up with a wrench.

4. Place the reverse clutch piston (17), without the seal ring, down over the drive pins to assure the heads of the pins will engage the slots in the piston without binding. Then, remove the piston from the reverse gear housing.

(b) If removed, install the oil transfer sleeve (8) in the reverse gear housing as follows:

1. Support the reverse gear housing on the bed of a hydraulic press with the forward face of the housing up.

2. Lubricate the outside of the oil transfer sleeve with engine oil.

3. Start the oil transfer sleeve straight into the bore of the gear housing. Then, place a wood block on top of the sleeve and under the ram of the press.

4. Bring the ram of the press down on the wood block and press the sleeve straight into the gear housing until the flange on the sleeve contacts the housing.

(c) Remove the reverse gear housing from the hydraulic press and support the housing (forward face down) on wood blocks approximately 6 inches high.

(d) Place the bronze thrust washer (fig. 3-91) over the aft end of the shaft with the wide flat face of the washer next to the bronze thrust washer. Install the snap ring in the groove in the shaft, then slide the steel thrust washer back over the snap ring.

(e) Apply a small amount of cup grease in each of the oil seal ring grooves in the reverse gear drive shaft. Then, slip the oil seal rings, in turn, over the end of the shaft and into the grooves in the shaft as shown in figure 3-91. Hook the ends of the oil seal rings together.

CAUTION

Do not spread the seal rings more than necessary to slip them over the shaft, to avoid breakage.

(f) With the reverse gear housing resting on the wood blocks, insert the forward end of the reverse gear drive shaft through the opening in the aft side of the gear housing and start it straight into the oil transfer sleeve. Lower the drive shaft through the oil transfer sleeve until the first oil seal ring contacts the oil transfer sleeve. Carefully work the shaft through the sleeve until all three seal rings are piloted into the sleeve and the thrust washer bears against the sleeve and gear housing, see figure 3-66.

CAUTION

Use care when installing the reverse gear drive shaft to avoid breaking the oil seal rings.

(g) Attach the reverse gear housings to the reverse gear adapter plate as follows:

1. Support the reverse gear housings (forward face down) on three wood blocks approximately 6 inches high, with the top of each housing facing the same direction.

NOTE

The three wood blocks should all be the same thickness, so the housings will be level.

2. Place a new gasket over the attaching bolts in the rear face of each reverse gear housing.

3. Position the reverse gear adapter plate over the top of the reverse gear housings, with the flat smooth side of the adapter plate facing the reverse gear housings, and the top of the plate facing the top of the housings.

4. Lower the adapter plate straight over the attaching bolts in both reverse gear housing and against the gaskets.

5. Install the elastic stop nuts and draw the adapter plate down tight against the housings. Tighten the nuts to 83-93 ft-lb torque.

(h) Raise the reverse gear housings and adapter plate up into a near vertical position. Place wood blocks under the aft end of each reverse gear drive shaft to support the assembly in this position.

NOTE

With the wood blocks in place, the top of the assembly should tilt back at approximately a 5° angle. This will prevent the assembly from tipping over forward.

(i) Place the seal ring expander (15, fig. 3-88) in the seal ring groove of the reverse gear housing; then, starting at approximate center of the expander, feed the thick lip of the seal ring

(14) into the groove next to the expander with the narrow lip of the seal ring pointed down into the gear housing.

(j) Place the reverse clutch piston (17) on a work bench with the drive pin slots in the rear face of the piston facing up. Place the seal ring expander (18) in the seal ring groove at the periphery of the piston; then, starting at the approximate center of the expander, feed the thick lip of the seal ring (19) into the groove next to the expander with the narrow lip of the seal ring facing the side of the piston incorporating the drive pin slots.

(k) Install the reverse clutch piston (17) in the reverse gear housing as follows:

1. Thread a piston remover tool J 4746 (T-head bolt) into each of the two tapped holes in the forward face of the reverse clutch piston.

2. Apply a light grade of engine oil to the seal ring in the piston and in the gear housing.

3. Place the piston over the reverse gear drive shaft, with the slots in the rear face of the piston in alignment with the drive pins in the gear housing.

4. Start the piston straight into the gear housing, and push the piston uniformly in over the drive pins using extreme care not to dislodge the seal rings from their grooves.

(l) Check the clearance between the piston seal rings and the reverse gear housing as follows:

1. Insert the end of a .006 inch feeler gage between the lip of the outer seal ring and the gear housing.

CAUTION

The end and edges of the feeler gage must be smooth and free of nicks or burrs.

2. Carefully slide the feeler gage around between the outer seal ring and the gear housing and check for any bind on the feeler gage. Then, check the clearance between the inner seal ring and the gear housing. If a bind occurs, the lip of the seal ring may have turned up or the piston may not be centrally located.

3. If the lip of either of the seal rings has turned up, remove the piston and install a new seal ring. Recheck the clearance.

4. If the piston is not centered, tap the face of the piston (opposite the bind) lightly with a plastic hammer. If the bind still exists, remove the piston and turn 120° or 240°, reinstall the piston and again check the clearance.

(m) Attach the reverse clutch plate (23) to the reverse ring gear (32) as follows:

1. Place the reverse ring gear on the work bench, with the forward face of the ring gear down.

2. Place the reverse clutch plate on top of the reverse ring gear.

3. Install the retaining ring (33) in the groove in the top inner diameter of the ring gear.

(n) Install the reverse clutch plate (23) and drive plate (22) in the reverse gear housing as follows:

1. Thread a piston remover tool J 4746 (T-head bolt) into each of the two tapped holes in the forward face of the reverse clutch drive plate.

2. Support the reverse clutch drive plate on an angle (rear face of the plate facing up) with the weight of the plate resting on the tools (T-head bolts).

3. Apply a small amount of cup grease on one end of each reverse clutch release spring (3). Then, insert the greased end of the springs into the sixteen holes in the rear face of the drive plate (22).

4. Place the reverse clutch plate and ring gear assembly against the reverse clutch drive plate, with the ring gear projecting through the center of the drive plate, (fig. 3-93).

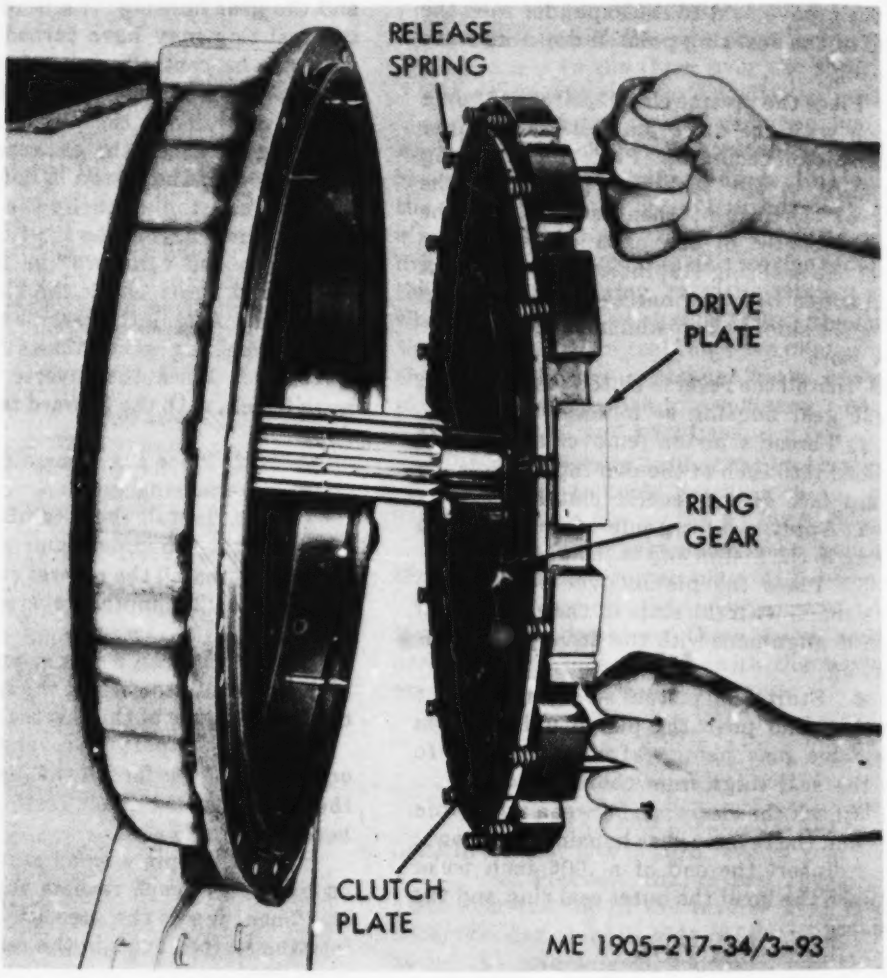


Figure 3-93. Installing reverse clutch plate and drive plate assembly into reverse gear housing.

NOTE

Immerse the reverse clutch plate in a light grade of engine oil for approximately one-half hour before assembling in the gear housing.

5. Raise the reverse clutch drive plate, clutch plate and release springs up to a near vertical position. Then, lift the drive plate assembly and pilot it over the drive shaft, as shown in figure 3-92, and start it straight into the gear housing. Use care to prevent the clutch plate from tipping forward or the release springs from dropping out of the drive plate.

6. Push the drive plate assembly straight into the gear housing until the release springs contact the reverse clutch piston.

7. Rotate the reverse clutch drive plate and align the dowel pin slots in the periphery of the drive plate with the slots in the gear housing. Install the three dowel pins (2, fig. 3-89) and push the pins in flush with the forward face of the plate.

(o) Install the reverse clutch drive plate retaining ring (21, fig. 3-88) in the gear housing as follows:

1. Place the retaining ring in the reverse gear housing and against the drive plate, with the open ends of the retaining ring at the bottom of the gear housing (fig. 3-90).

2. Clamp a board across the face of the gear housing with a 1 inch wood block at each end between the board and the drive plate.

3. Tighten the clamps and draw the drive plate straight into the gear housing until the retaining ring groove in the housing is exposed.

4. If the three dowel pins (2, fig. 3-89) extend above the face of the drive plate, push or tap the pins down flush with the face of the drive plate.

5. Starting at the lower edge of the gear housing, feed the retaining ring in the groove in

the gear housing. Then, remove clamps, board, and blocks.

NOTE

The ends of the retaining ring, when installed in the gear housing, must always be directly above the oil drain hole in the gear housing.

(p) Install a retaining ring retaining spring pin (20) in each of the three holes in the forward face of the drive plate. Then, tap the spring pins in the drive plate to within 1/16 inch of the outer surface of the retaining ring with a punch and hammer.

(q) Lubricate the planetary gear thrust washer (7) with engine oil. Then, place the thrust washer over the reverse gear drive shaft and against the oil transfer sleeve.

(r) Lubricate one of the reverse sun gear thrust washers (26) with engine oil. Then, place the thrust washer over the planetary hub and against the inside face of the hub.

(s) Place the sun gear over the planetary hub and through the planetary gears (large inside diameter of sun gear facing up), and against the thrust washer, (fig. 3-89).

(t) Place the planetary gear assembly with sun gear over the end of the drive shaft (oil collector ring side facing the ring gear) as shown in figure 3-94. Aline the splines in the sun gear with the splines on the drive shaft. Slide the assembly straight back on the drive shaft and through the ring gear until it contacts the planetary gear thrust washer.

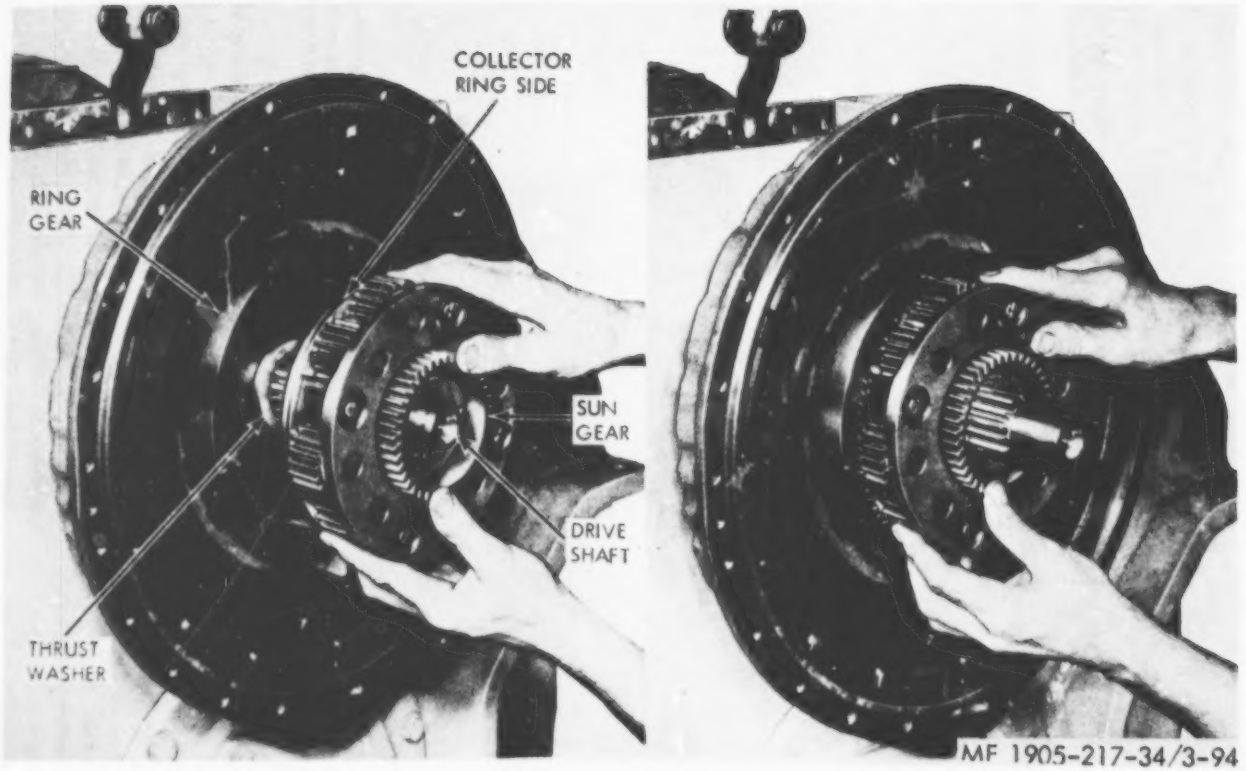


Figure 3-94. Installing reverse planetary gear assembly and sun gear on reverse gear drive shaft.

NOTE

When installing the planetary gear assembly, the reverse ring must be raised up to permit the planetary gears to mesh with the internal teeth of the ring gear.

(u) Lubricate the second reverse sun gear thrust washer (26, fig. 3-89) with engine oil; then, place the thrust washer over the end of the drive shaft and over the end of the planetary hub.

(v) Install the planetary gear retaining washer (30) over the end of the drive shaft and against the end of the planetary hub.

(w) Install the planetary gear retaining ring (27) in the groove in the drive shaft next to the retaining washer, using a pair of snap ring pliers.

f. Installation.

(1) Affix a new gasket to the forward face of each reverse gear housing.

(2) Support the reverse gears and adapter plate with two rope slings and a chain hoist.

(3) Lubricate the pilot bearing surface and the splines on the forward end of each reverse gear drive shaft with engine oil.

(4) With the blocking still in place beneath the two flywheel housings, same as when the reverse gears and adapter plate assembly was removed, position the assembly directly in back of the engines with the forward end of the drive shafts in line with the center of the flywheels.

(5) Move the reverse gears and adapter plate forward and pilot the drive shafts straight into and through the hub of each forward clutch plate.

NOTE

If the splines on the drive shafts do not readily engage those in the hub of each clutch plate, press forward slightly on the assembly and at the same time, turn one or both of the drive shafts slightly to aline the splines.

(6) With the drive shafts entered into the hubs of the clutch plates, continue to push the assembly forward and pilot the drive shafts straight into the pilot bearings, then enter the pilot on the reverse gear housings straight into the flywheel housings.

NOTE

If the sun gear does not readily enter the forward clutch drive plates, rotate the drive shafts very slowly until the sun gears enter the drive plates.

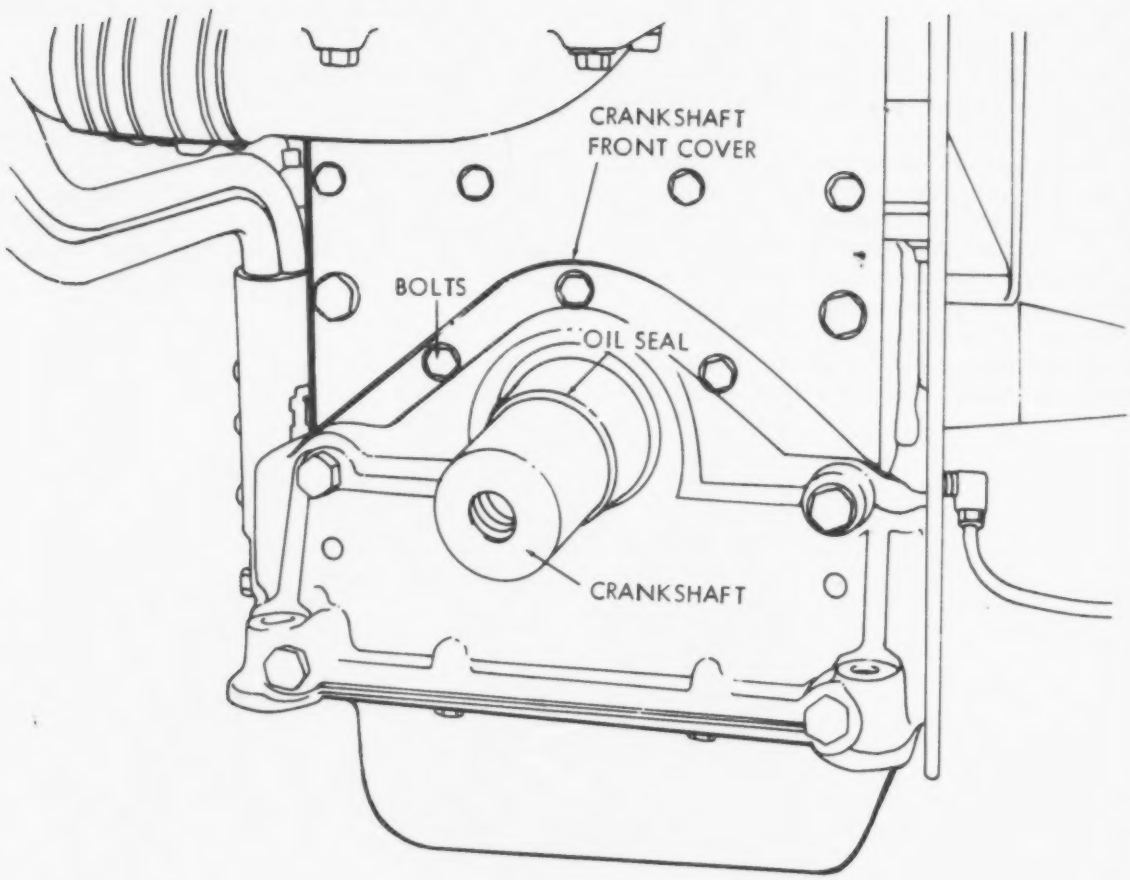
(7) Install the bolts and lock washers securing the reverse gear housings to the flywheel housings. Tighten the bolts to 30-35 ft-lb torque.

(8) Install the power transfer gear assembly (para 3-15).

3-27. Crankshaft Front Cover

a. General.

(1) The crankshaft front cover is mounted against the end plate at the lower front end of the engine as shown in figure 3-95. It serves as a housing for the vibration damper. The engine is supported at the front end by means of engine supports attached to the front cover.



ME 1905-217-34/3-95

Figure 3-95. Crankshaft front cover, removal and installation.

b. Removal.

(1) Remove oil pan (para 3-18).

(2) Remove pully, vibration damper and front oil seal (para 3-22).

(3) Remove the mounting bolts and washers (fig. 3-96) and remove the front cover and gasket from the end plate.

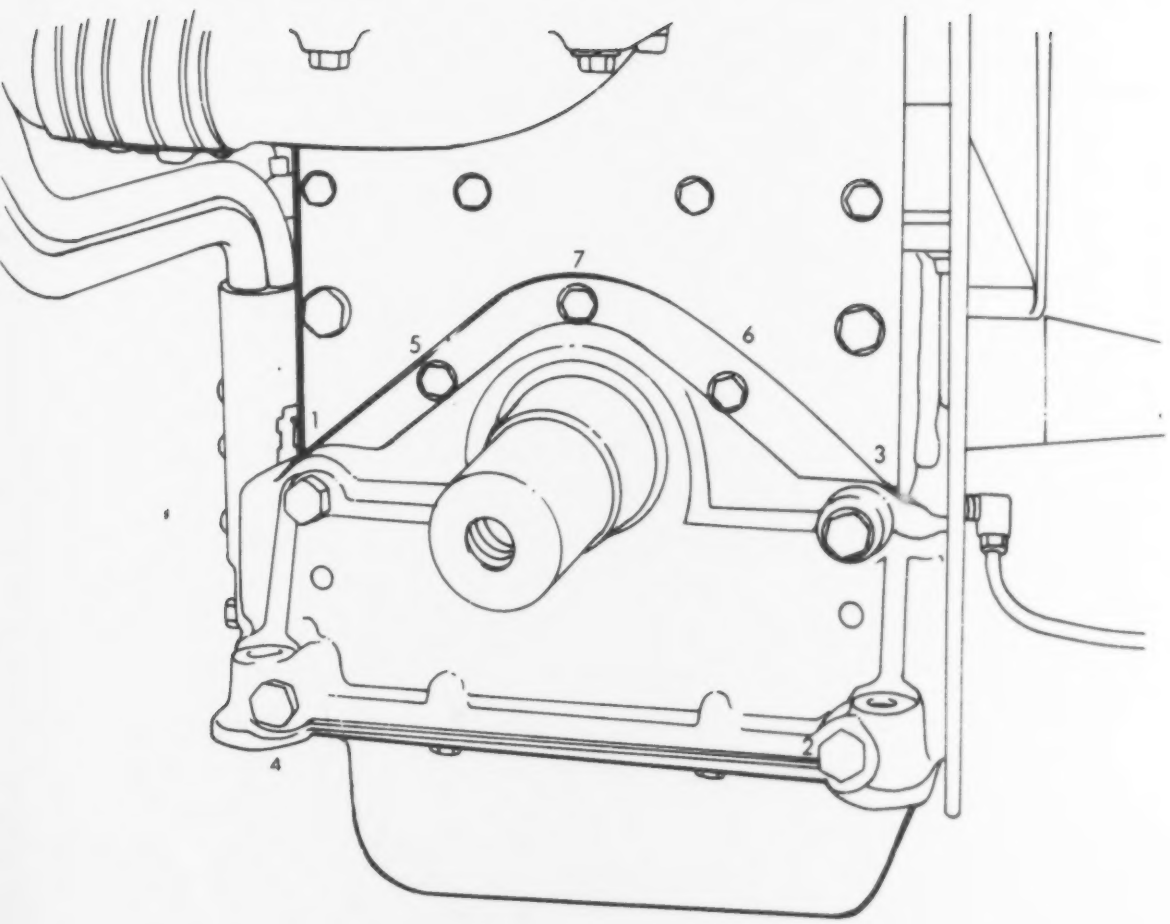


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Figure 3-96. Crankshaft front cover bolt tightening sequence.

c. Cleaning, Inspection, and Repair.

(1) Clean front cover with solvent (FED. SPEC. PD-680) and dry thoroughly.

(2) Inspect for cracks, breaks, missing hardware.

(3) Replace gasket.

(4) Replace a front cover that is damaged beyond repair.

d. Installation.

(1) Install the crankshaft front cover by tightening the bolts in the sequence shown in figure 3-96.

(2) Tighten 3/8" x 24 bolts to 25-30 ft-lbs. and tighten 1/2" x 13 bolts to 80-90 ft-lbs.

3-28. Crankshaft

a. Removal.

(1) Drain engine crankcase TM 55-1905-217-12 (para 3-2).

(2) Remove engine (para 2-8).

(3) Remove all accessories and assemblies with attaching parts as necessary to mount engine on overhaul stand.

(4) Remove oil pump (para 3-19).

(5) Remove pully and vibration damper (para 3-22).

(6) Remove the transfer gear assembly and flywheel housing (para 3-23).

(7) Remove the transmission and flywheel (para 3-26).

(8) Remove connecting rod bearing caps (para 3-20).

(9) Remove main bearing caps and shells, and remove thrust washers from each side of rear main bearing (para 3-25).

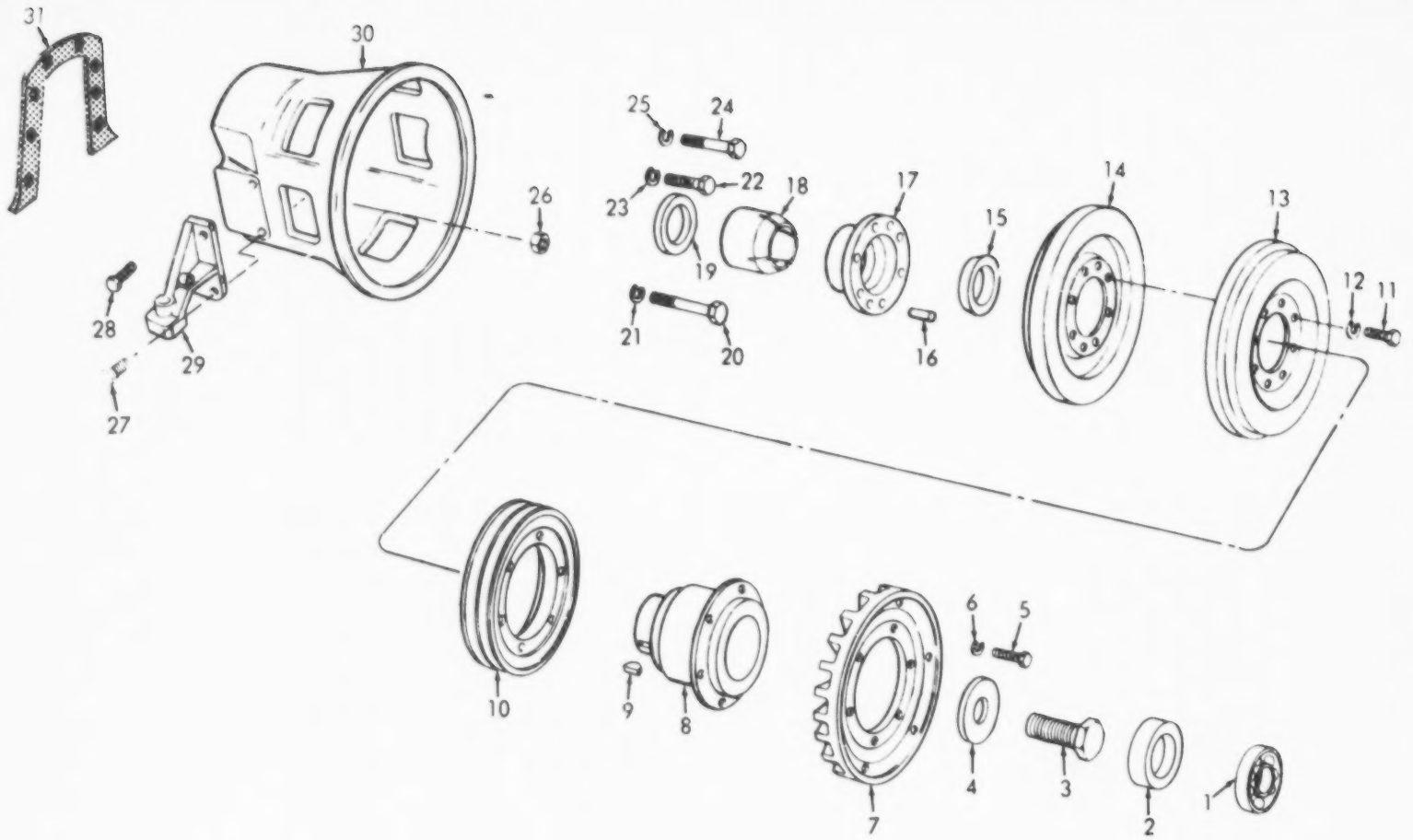
(10) Remove the crankshaft front cover (para 3-27).

(11) Remove the crankshaft, including the timing gear at the rear and the oil pump drive gear at the front.

b. Disassembly.

(1) Remove bolts (2, fig. 3-97) and lockwashers (3) and remove the crankshaft gear (4) from the crankshaft.

Key to figure 3-97.
1. Plug
2. Bolt
3. Lockwasher
4. Gear, crankshaft
5. Gear, oil pump drive
6. Key
7. Dowel pin
8. Crankshaft



ME 1905-217-34/3-97

Figure 3-97. Crankshaft, disassembly and reassembly.

(2) Use a puller to remove the oil pump drive gear (5) from crankshaft. Remove key (6).

(3) Remove dowel pins (7) from crankshaft.

c. Cleaning.

(1) Clean the crankshaft and gears with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly.

(2) Remove plugs, (1, figure 3-97) from crankshaft and clean out all oil passages thoroughly.

d. Inspection and Repair. Used crankshafts will sometimes show a certain amount of ridging caused by the groove in the upper main bearing shell. If this ridge is not removed before new bearing shells are installed, localized high unit pressures on the bearings will result during engine operation. A ridge exceeding .0002 inch or more must be removed.

(1) Support the crankshaft on its front and rear journals in V-blocks or in a lathe.

(2) The ridges may be removed by working crocus cloth, wet with fuel oil, around the circumference of the crankshaft journal. Rotate the crankshaft frequently to eliminate an out-of-round condition. If the ridges are greater than .0005 inch, first use 120 grit emery cloth to clean up the ridge, followed by the use of 240 grit emery cloth for finishing. Then, wet crocus cloth should be used for the polishing operation. If the ridges are greater than .001 inch, the crankshaft may have to be replaced and the used crankshaft reground at depot.

(3) Measure all of the main and connecting rod gearing journals. The journals should be measured at several places on the circumference in order to determine the smallest diameter, in case the journals have worn out-of-round. Taper on the journals of a used shaft should not exceed .0015 inch, and out-of-round should not exceed .0010 inch. (The maximum taper on a new shaft is .0005 inch and the maximum out-of-round is (.0025 inch.) Excessive taper or out-of-round indications require that the crankshaft be replaced.

(4) Check the alinement at the adjacent intermediate journals using a dial indicator. When runout on adjacent journals is in the opposite direction, the sum must not exceed .003 inch total indicator reading. When runout on adjacent journals is in the same direction, the difference must not exceed .003 inch total indicator reading. The crankshaft must also be replaced if the runout limit is greater than: .002 inch on journal number 2; .004 inch on number 3; .006 inch on number 4; .004 inch on number 5; .002 inch on number 6.

NOTE

Crankshaft failures are rare and, when one cracks or breaks completely, it is very important to make a thorough inspection for contributory factors. Unless abnormal conditions are discovered and corrected, there will be a repetition of the failure.

(5) Check thrust surfaces for evidence of excessive wear or roughness. In many instances, only slight grinding or "dressing up" of the thrust surface is necessary. In such cases, use of new standard thrust washers will probably hold the end thrust clearance within the specified limits of .004 inch to .011 inch for new parts or a maximum of .018 inch with a used crankshaft.

(6) Inspect the keyways for evidence of cracks or worn condition, and replace the shaft if necessary.

(7) Carefully inspect the crankshaft in the area of the rear oil seal contact surface for evidence of rough or grooved condition. Any imperfections of the oil seal contact surface will result in oil leakage at this point.

e. Reassembly. Reassemble the crankshaft in reverse order of disassembly (*b* above).

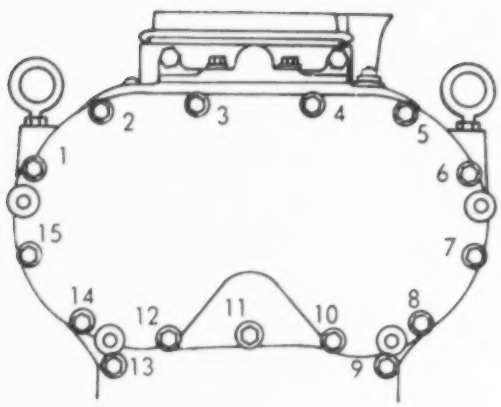
f. Installation. Install the crankshaft in reverse order of removal (*a* above).

3-29. Camshaft and Balance Shaft

a. General. If the transmission and flywheel housing have been removed, the camshaft and balance shaft can be removed from the rear of the engine. They can also be removed from the front of the engine by using a special adapter plate and gear puller. This method eliminates the requirement for transmission and flywheel housing removal.

b. Removal (Transmission and Flywheel Housing Removed).

(1) Remove bolts and washers shown in figure 3-98 and remove the balance weight cover.



ME 1905-217-34/3-98

Figure 3-98. Balance weight cover, removal and installation and bolt tightening sequence.

(2) Remove cam followers and push rods (para 3-8).

(3) Place a wood block between the balance weights (fig. 3-99) or wedge a clean rag between the cam and balance shaft drive gears on the rear of the engine.

(4) Detach the gear nut retainer (18 and 22, fig. 3-100) after removing the bolts (19 and 23).

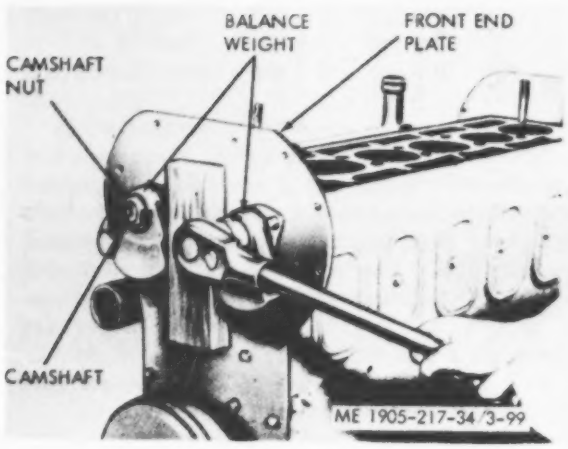
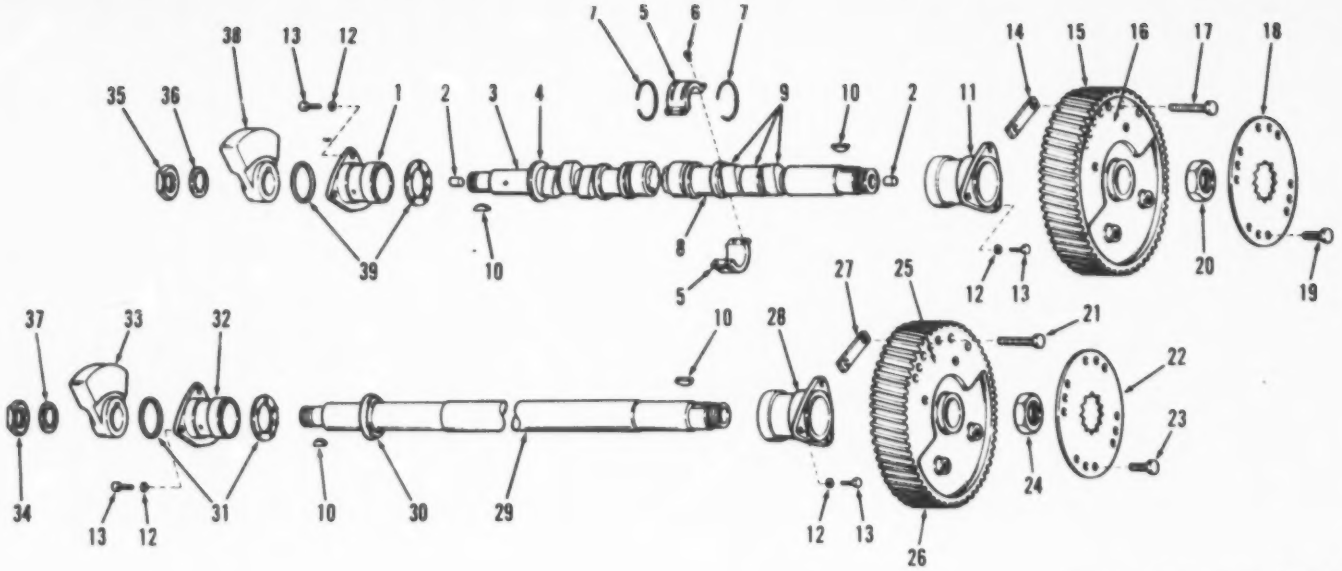


Figure 3-99. Loosening nut on camshaft or balance shaft.



1. Front camshaft bearing
2. Plug
3. Camshaft
4. Thrust shoulder
5. Intermediate bearing
6. Setscrew
7. Lock ring
8. Intermediate journal
9. Cam
10. Woodruff key
11. Rear camshaft bearing
12. Lock washer
13. Bearing retainer bolt
14. Rear balance weight
15. Camshaft gear-L. H. helix
16. Integral balance weight
17. Bolt
18. Gear nut retainer
19. Retainer bolt
20. Nut
21. Retainer bolt
22. Gear nut retainer
23. Gear nut retainer bolt
24. Balance shaft nut
25. Balance shaft weight
26. Balance shaft gear-R. H. helix
27. Balance shaft balance weight
28. Balance shaft bearing
29. Balance shaft
30. Thrust shoulder
31. Balance shaft thrust washer
32. Balance shaft front bearing
33. Balance weight assembly
34. Balance shaft nut
35. Camshaft nut
36. Lock washer
37. Lock washer
38. Balance weight assembly
39. Camshaft thrust washer

Figure 3-100. Camshaft and balance shaft, exploded view.

(5) Loosen the nuts on each end of the cam and balance shaft. Remove the nut (34, 35) and lock washer (36, 37) from the balance weight end of each shaft. Do not remove the nut from the drive gear end of the shafts.

(6) Remove the balance weights (33, 38) by prying with two heavy screwdrivers or pry bars between the heads of the bearing retainer bolts (13) and the balance weights.

(7) On B engines, remove the thrust washers (31, 39) between the bearings and the balance weight hubs.

(8) Remove the set screws (6) that secure the camshaft intermediate bearings.

(9) The three bolts that secure the cam and balance shaft bearings to the rear end plate of the engine may be removed by inserting a socket wrench through the hole in the webs of the cam and balance shaft drive gears.

(10) Withdraw the cam and balance shafts (3, 29) from the rear end of the cylinder block.

(11) If the thrust washers (39, 31) located between the bearings and thrust shoulders at the front end of the shaft on the B engines are not removed with the shafts, they should be pulled out when removing the bearings.

(12) The cam and balance shaft front bearings (1 and 32) (and thrust washers B engines) may be removed after taking out the bolts that hold the bearings to the end plate and cylinder block. Pry under the bearing flange with a suitable tool if the bearing cannot be withdrawn by hand.

c. Removal. (Transmission and Flywheel Housing Installed).

(1) Remove bolts and washers shown in figure 3-98 and remove the balance weight cover.

(2) Remove the parts, accessories and assemblies that are necessary to facilitate the removal of the flywheel housing hole cover over the camshaft and the front balance weight cover.

(3) Remove the cam followers and push rods (para 3-8).

(4) Remove the front balance weight cover and place a wood block between the balance weights (fig. 3-98).

(5) Detach the gear nut retainer (18 and 22, fig. 3-100) after removing the bolts (19 and 23).

(6) Loosen and remove the nut at each end of the camshaft.

(7) Remove the balance weights (33 and 38) by prying with two heavy screwdrivers or pry bars between the heads of the bearing retainer bolts and the balance weights.

(8) Remove the thrust washers between the bearings and balance weight hubs (B engines only).

(9) Remove the set screws that secure the camshaft intermediate bearings.

(10) Remove the three bolts that secure the camshaft bearing to the front end plate.

(11) Install the camshaft gear puller, J 1902-01, four spacers, J 6202-2 and camshaft gear puller adapter plate J 6202-1 on the camshaft gear.

(12) Turn the center screw of the puller clockwise to disengage the camshaft gear.

(13) Do not remove the puller or adapter plate until the camshaft is reinstalled. The adapter plate, secured to both the flywheel housing and the camshaft gear, will hold the gear (thrust washer also on D engines) securely in place and in alinement which will aid in the reinstallation of the camshaft.

(14) Remove the front bearing from the camshaft and pull out the inner thrust washer (B engines). Then pull the camshaft and intermediate bearings from the cylinder block.

d. Disassemble Camshaft or Balance Shaft.

(1) Remove the gear from the shaft.

(2) Slide the rear bearing, and the thrust washer (D engines) off the shaft.

(3) Remove the lock rings from the camshaft intermediate bearings and free the two halves of each bearing.

(4) To facilitate the removal of any foreign matter lodged behind the camshaft oil passage end plugs, remove plugs as follows:

(a) With the camshaft still clamped in the vise, make an indentation in the center of one of the end plugs with a 31/64 inch carboloy tip drill.

(b) To aid in breaking through the hardened surface of the plug, punch a hole as deep as possible with a center punch.

(c) Use a 1/4 inch carboloy tip drill and drill a hole straight through the center of the plug. Then, enlarge the hole with a 5/16 inch carboloy tip drill.

(d) Tap the drilled hole with a 3/8 inch-16 tap.

(e) Thread the 3/8 inch-16 adapter J 8183 into the plug and attach the slide hammer J 6471-1 to the adapter. Remove the plug by striking the weight of the hammer against the handle.

(f) Insert a 3/8 inch diameter steel rod into the camshaft oil passage and drive the remaining plug out.

f. Inspection and Repair.

(1) Examine the cams and journals. If the surfaces are badly scored or worn the camshaft will have to be replaced.

(2) Check the cam followers if the cam surfaces are scored.

(3) Inspect both faces of the thrust washers. Those that are excessively scored or worn must be replaced. The clearance between the thrust washer and the thrust shoulder of the shafts is .004 inch to .012 inch with new parts, or a maximum of .018 inch with used parts.

(4) Examine the faces of the shaft end bearings and any other surface which comes into contact with the thrust washers. Parts that are badly marred must be replaced, slight scratches may be cleaned up with an oil stone.

(5) Inspect the bushings in the shaft end bearings. Replace the bushings or end bearing assemblies if they are worn excessively or the bushings have turned within the bearing. New bushings must be finished bored to a 20 rms finish after installation and tested for the correct press fit. The correct press fit is indicated if the bushing does not turn when a 2000 pound end load is applied. The inside diameter of the bushings must be square with the rear face of the bearing within .0015 inch total indicator reading, and concentric with the outside diameter of the bearing retainer within .002 inch total indicator reading. The bushings must project from .045 inch to .055 inch from each end of the bearing.

(6) The clearance between the camshaft and balance shaft end journals and the end bearing bushings is .0025 inch to .004 inch with new parts, or a maximum of .006 inch with used parts.

(7) Replace excessively scored or worn camshaft intermediate bearings. The clearance between the camshaft journals and the intermediate bearings is .0025 inch to .005 inch with new parts, or a maximum of .009 inch with worn parts. Examine the intermediate bearing lock screws and the tapped holes in the block. Damaged holes in the cylinder block may be plugged, redrilled and tapped. Discard lock screw with damaged threads.

g. Reassembly.

(1) Install new end plugs (2, fig. 3-100) in the camshaft.

(2) Apply grease to the steel face of end thrust washers. Then, place a thrust washer (39 and 31) against each end of the cam and balance shaft rear bearings. The steel faces of the thrust washers must be towards the bearing.

(3) Lubricate the rear cam and balance shaft journals and slide the rear bearings on each shaft with the mounting flange of the bearing toward the gear end of the shaft.

(4) Install the gears on the shaft.

(5) Lubricate the camshaft intermediate bearing journals (8). Then, place the two halves of each intermediate bearing (5) on a camshaft journal and lock the halves together with the two lock rings (7). Install each lock ring with the gap over the upper bearing and the ends on equal distance above the split line of the bearing.

h. Installation (Flywheel Housing and Transmission Removal).

(1) Insert the front end of the camshaft into the opening on the opposite side of the blower. Push the camshaft into the cylinder block until the camshaft gear teeth almost engage the teeth of the idler gear. Use care when installing the camshaft to avoid damaging the cam lobes.

NOTE

The right hand gear (viewing the engine from the flywheel end) whether it is attached to the cam or balance shaft has left-hand helical teeth.

(2) Aline the timing marks on the mating gears as shown in figures 3-67 and 3-68 and slide the camshaft gear in place.

(3) Secure the camshaft rear bearing (11, fig. 3-100) to the cylinder block with three bolts and lock washers. The camshaft gear may be turned to accommodate the bolts through the hole in the gear web. Tighten the bolts to 35-40 ft-lb torque.

(4) Insert the balance shaft into the bore in the cylinder block and push it in until the teeth of the balance shaft gear almost engage the camshaft gear teeth.

(5) Aline the timing marks on the mating gears as shown in figures 3-67 and 3-68, and slide the balance shaft gear into place.

(6) Secure the balance shaft rear bearing. Use the same procedure as outlined for the camshaft rear bearing, step 3.

(7) Apply grease to the steel face of each thrust washer (39 and 31, fig. 3-100). Then, place a thrust washer against the inner end of the cam and balance shaft front end bearing (B engines). The steel face of the thrust washer must be against the bearing.

(8) Install the cam and balance shaft front end bearings with the bolts and lock washers. Tighten the bolts to 35-40 ft-lb torque.

CAUTION

Install the front bearings with care to avoid dislodging the thrust washers. Do not hammer the bearings into the cylinder block.

(9) Apply grease to the steel face of each thrust washer (39 and 31) and place them so that the steel faces are against the outer end of the cam and balance shaft front bearings (1 and 32).

(10) Turn the camshaft intermediate bearings until the holes in the bearings are in alinement with the threaded holes in the cylinder block. Install the lock screws and tighten them to 15-20 ft-lb torque.

(11) Install the front balance weights on the shafts.

(12) Place an internal tooth lock washer (36 and 37) on the end of each shaft and start the nuts (34 and 35) on both shafts.

(13) Use a wood block, figure 3-98 between the balance weights or wedge a clean cloth between the cam and balance shaft gears to prevent their turning. Tighten the nuts to 300-325 ft-lb torque.

(14) Install the cam and balance shaft gear nut retainers (18 and 22, fig. 3-100) with the bolts (19 and 23) and lock washers. Tighten the bolts to 35-39 ft-lb torque.

(15) Check the clearance between the thrust washer and the thrust shoulder (4 and 30) of both the cam and balance shaft. The specified clearance is .004 inch to .012 inch with new parts, or a maximum of .018 inch with used parts.

(16) Check the backlash between the mating gears. The specified backlash is found in paragraph 3-17*a* (9).

(17) Replace the parts, accessories and assemblies that were removed from the engine and refill the cooling system.

i. Installation (Flywheel Housing and Transmission Installed).

(1) Install a Woodruff key in the drive gear end of the camshaft and insert this end into position from the front end of the engine. Push the shaft in until it slides into the rear end bearing. Use care in the installation of the camshaft to prevent damage to the cam lobes.

(2) On the D engines, apply grease to the steel face of the thrust washer and install it with the steel face against the bearing.

(3) Aline the key in the shaft with the keyway in the camshaft drive gear and start the shaft into the gear. Tap the shaft into the gear with a soft (plastic or rawhide) hammer.

CAUTION

On the D engines, make sure the thrust washer is in the correct position to prevent pushing the bushing into the bearing or damage to the bushing.

(4) Remove the camshaft gear puller, spacers and adapter plate. Finger tighten the gear retaining nut on the shaft.

(5) Install the front end bearing (and thrust washers B engines) with the bolts and lock washers. Tighten the bolts to 35-40 ft-lb torque.

CAUTION

Apply grease to the steel faces of the thrust washers and insure that the steel faces are towards the bearing.

(6) Install the balance weight on the front of the camshaft.

(7) Start the balance weight retaining nut (35, fig. 3-100) and lock washer on the camshaft. Place a wood block between the balance weights (fig. 3-98). Tighten the gear retaining nut; then, tighten the balance weight nut to 300-325 ft-lb torque.

(8) Aline the holes in the camshaft intermediate bearings with the tapped holes in the top of the cylinder block. Install and tighten the lock screws to 15-20 ft-lb torque.

(9) Replace the parts, accessories and assemblies that were removed from the engine and refill the cooling system.

(10) Install the cam followers and push rods (para 3-14).

(11) Install the balance weight cover and secure with nuts and bolts as shown in figure 3-98.

3-30. Cylinder Block

a. Removal.

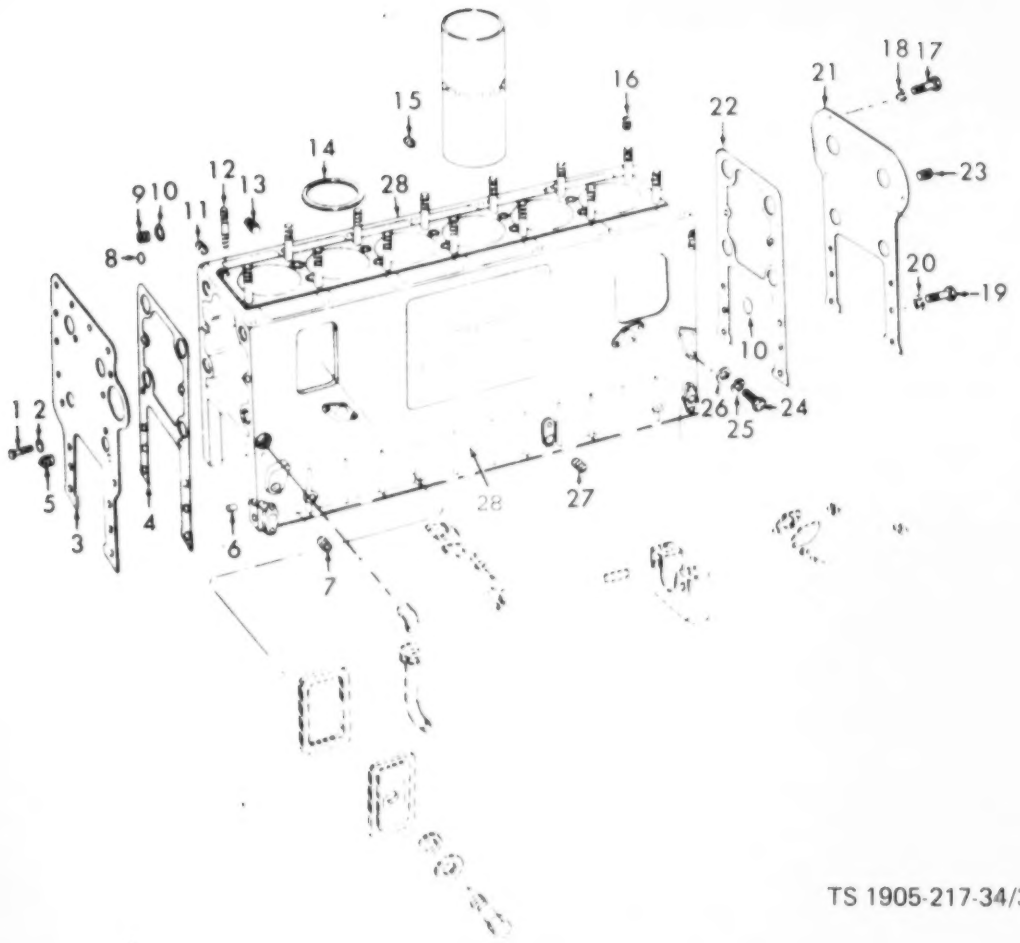
(1) Remove the rocker arms, camfollowers, push rods, and valves (paras 3-14 and 3-15).

(2) Remove the idler gear and hole spacer (para 3-16).

(3) Remove the pistons, connecting rods and liners (paras 3-20 and 3-21).

(4) Remove the crankshaft (para 3-28) and camshaft and balance shaft (para 3-29).

b. Disassembly. Refer to figure 3-101 and disassemble the cylinder block.



1. Screw
2. Lockwasher
3. Rear end plate
4. Gasket
5. Plug, pipe
6. Pin, headless
7. Plug, socket-Ld
8. Plug, expansion
9. Plug, pipe
10. Gasket
11. Plug, pipe
12. Stud
13. Plug, pipe
14. Insert, cylinder sleeve
15. Plug, pipe
16. Plug, pipe
17. Screw
18. Lockwasher
19. Screw
20. Lockwasher
21. Front end plate
22. Gasket
23. Plug, pipe
24. Screw
25. Lockwasher
26. Flat washer
27. Plug, pipe
28. Cylinder block

Figure 3-101. Cylinder block, disassembly and reassembly.

c. Cleaning, Inspection, and Repair.

(1) Clean all metal parts with cleaning solvent (FED. SPEC. PD-680), and dry thoroughly.

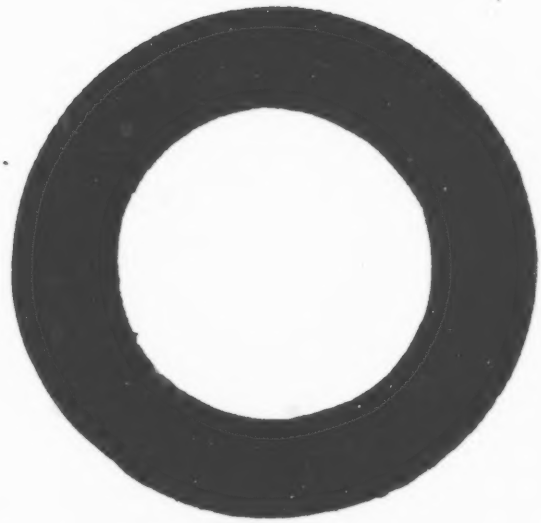
(2) Inspect for defective end plates, plugs and hardware. Inspect block for cracks and evidence of excessive wear.

(3) Replace defective parts as necessary.

(4) Replace all gaskets.

d. Reassembly. Refer to figure 3-101 and reassemble the cylinder block.

e. Installation. Install in reverse order of removal (*a* above).



CHAPTER 4

REPAIR OF CONTROL SYSTEMS

Section I. ELECTRICAL SYSTEM

1. General

Description of the elctrical system and components is contained in the Operator and Organizational Maintenance Manual TM 55-1905-217-12. See figures 1-2, 1-3, and 1-4 as applicable for wiring diagrams. This section contains repair procedures for the alternator and electrical starting motor.

2. Alternator

a. *In-Vessel Testing.* Perform in-vessel test (TM 55-1905-217-12, para 4-48).

b. *Removal.* Remove alternator (TM 55-1905-217-12, para 4-48).

CAUTION

Do not remove alternator without first disconnecting the negative battery cable. If battery must be removed, disconnect negative cable first.

c. *Disassembly into Subassemblies (Hulls 8500-8519 and 8520-8539).*

(1) Clamp the driven pulley (3, fig. 4-1) in a vise, using an old belt or suitable rag to prevent damage to the pulley.

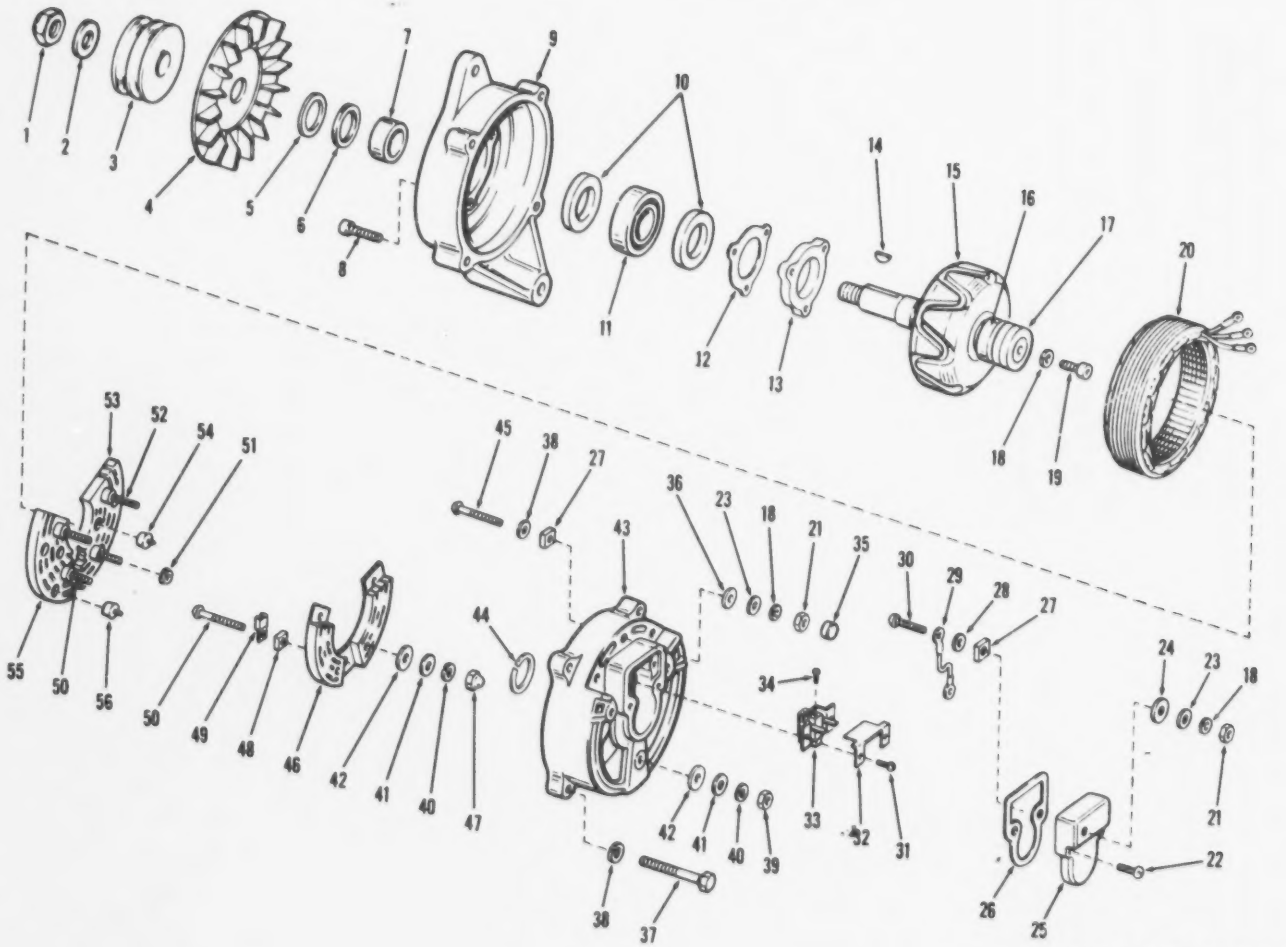


Figure 4-1. Alternator-exploded view, (Hulls 8500-8519 and 8520-8539).

Key to figure 4-1.

1. Self-locking nut
2. Flat washer
3. Driven pulley
4. Fan
5. Flat washer
6. Felt washer
7. Pulley spacer
8. No. 10-32 x 1 in. retainer screw
9. Front housing
10. Grease seal
11. Ball bearing
12. Retainer gasket
13. Front bearing retainer
14. Woodruff key
15. Rotor assembly
16. Ball bearing
17. Slip rings
18. No. 10 lock washer
19. No. 10-32 x 5/8 in. hex socket screw
20. Stator assembly
21. No. 10-24 hex nut
22. No. 8 x 3/4 in. tapping screw
23. Flat washer
24. Insulating washer
25. Rear cover
26. Cover gasket
27. Terminal insulator
28. Flat washer
29. Field wire
30. No. 10-24 x 3/4 in. carriage bolt
31. No. 8 x 1/2 in. tapping screw
32. Shunt lead insulator
33. Brush assembly
34. No. 4-40 x 1/4 in. lock screw
35. Stud cap
36. Insulating washer
37. Thru bolt
38. No. 12 lock washer
39. 1/4-28 hex nut
40. 1/4-in. lockwasher
41. Flat washer
42. Insulating washer
43. Rear housing
44. Bearing retainer
45. No. 10-24 x 1 1/8 in. carriage bolt
46. Isolation diode assembly
47. 1/4-28 acorn nut
48. Insulator
49. Terminal lug
50. 1/4-28 x 1 1/4 in. carriage bolt
51. Diode ring insulator
52. 1/4-28 x 2 1/8 in. carriage bolt
53. Negative rectifier diode heat sink
54. Negative rectifier diode heat sink
55. Positive rectifier diode heat sink
56. Positive rectifier diode heat sink

(2) Remove self locking nut (1) and washer from the shaft.

(3) Pull alternator from the pulley (3). A ght rocking of the alternator body will help sen a tight pulley. Remove fan (4).

(4) Remove two tapping screws (22) and nove the rear cover (25) and cover gasket (26).

(5) Remove two lock screws (34) connecting ps to terminals.

(6) Remove two tapping screws (31) securing the brush assembly (33) and insulator (32) to the housing.

(7) Remove four thru bolts (37) and lock washers (38) which hold front and rear sections together. Use a screwdriver and a wedge to pry the halves apart at the housing "ears".

CAUTION

Do not insert sharp tools (screwdriver, etc.) between stator and housing. They may cause permanent damage to the stator windings or laminations.

(8) After the alternator has been opened, push against the outer slip ring with thumb to completely separate the two sections.

NOTE

When the alternator is separated, the rotor assembly will come out with the front housing; the stator will come out with the rear housing.

d. Disassembly of Rear Housing Assembly (Hulls 8500-8519 and 8520-8539).

NOTE

Make a note of all washers and insulators that are removed so they can be properly replaced during reassembly.

(1) Remove three stud caps (35, fig. 4-1) and hex nuts (21) from three-phase winding carriage bolts (45) and disconnect stator wires.

(2) Separate stator assembly (20) from the rear housing (43).

(3) Remove three hex nuts (21) securing carriage bolts (45) to rear housing. Remove the carriage bolts, washers (18, 23, 36, 38), and terminal insulators (27).

(4) Remove the screw securing the ground lead to the negative rectifier diode heat sink (53).

(5) Remove hex nuts (39) and washers (40, 41 and 42).

(6) Remove entire diode assembly (with isolation diode attached) from housing.

(7) Remove two acorn nuts (47) and washers (40, 41 and 42). Separate the isolation diode assembly (46) from the diode assembly. Remove carriage bolt (50), terminal lug (49) and insulator (48) from isolation diode assembly (46).

(8) Individual diode removal.

CAUTION

When applying soldering iron to a diode lead connection, grasp the diode connection terminal with long nose pliers (between soldering iron and diode) to prevent overheating and thereby damaging a diode.

(a) Unsolder the connecting wires from the diodes.

(b) Set the diode plate on a 3/4 inch to 1 inch diameter tubular tool or jig with the terminal facing down.

(c) Use a small round tool and arbor press to press the diode from the heat sink.

CAUTION

Do not hammer diode to remove it since shock of this magnitude will damage the diodes.

e. Disassembly of Front Housing Assembly (Hulls 8500-8519 and 8520-8539).

(1) Remove woodruff key (14, fig. 4-1), flat washer (5), felt washer (6) and pulley spacer (7) from shaft.

(2) Remove three retainer screws (8).

(3) Press the rotor assembly (15) from the front housing (9) using an arbor press.

NOTE

It is not necessary to remove the grease seal (10) unless it is damaged.

(4) If necessary, remove the grease seal (10) by tapping on the seal through opening in the housing with a flat face punch.

(5) Remove the front ball bearing (11) from rotor shaft with a bearing puller.

(6) Remove front bearing retainer (13) grease seal (10) and retainer gasket (12) from rotor shaft.

(7) Remove the hex socket screw (19) from the end of the shaft and remove lock washer (18).

(8) Unsolder two connections on the slip rings (17) being careful not to damage the fiber washer between the rings or break the wires.

(9) Thread a ¼-28 x 1¼ inch machine screw into the end of the shaft (slip ring end). As the screw is tightened the slip rings will back off the shaft.

(10) Remove ball bearing (16) from rotor shaft with bearing puller.

f. Disassembly into Subassemblies (Hulls 8540-8560 and 8580-8519).

(1) Clamp the pulley (3, fig. 4-2), in a vise using an old drive belt or suitable rag to prevent damage to the pulley.

Key to figure 4-2.

1. Locking nut
2. Steel washer
3. Pulley
4. Fan assembly
5. Flat washer
6. Felt washer
7. Pulley spacer
8. Retaining screw
9. Front housing
10. Bearing seal
11. Front bearing
12. Retainer gasket
13. Front bearing retainer
14. Woodruff key
15. Rotor
16. Rear bearing
17. Slip ring assembly
18. Lockwasher
19. Cap screw
20. Stator and leads assembly
21. Carriage bolt
22. Field diode assembly
23. Square insulator
24. Positive rectifier diode
25. Positive heat sink
26. Round washer
27. Carriage bolt
28. Flat washer
29. Square insulator
30. Diodes wiring harness
31. Negative heat sink
32. Carriage bolt
33. Negative rectifier diode
34. Rear bearing retainer
35. Rear housing
36. Lockwasher
37. Bolt
38. Insulator washer
39. Flat washer
40. Lockwasher
41. Hex nut
42. Brush and capacitor assembly
43. Self-tapping screw
44. Shunt lead insulator
45. Tapping screw
46. Flat washer
47. Insulator washer
48. Hex nut
49. Flat washer
50. Insulator washer
51. Lockwasher
52. Hex nut
53. Plastic cap
54. Carriage bolt
55. Brush connecting cable
56. Flat washer
57. Square insulator
58. Felt gasket
59. Rear housing cover
60. Self-tapping screw
61. Insulator washer
62. Flat washer
63. Lockwasher
64. Hex washer

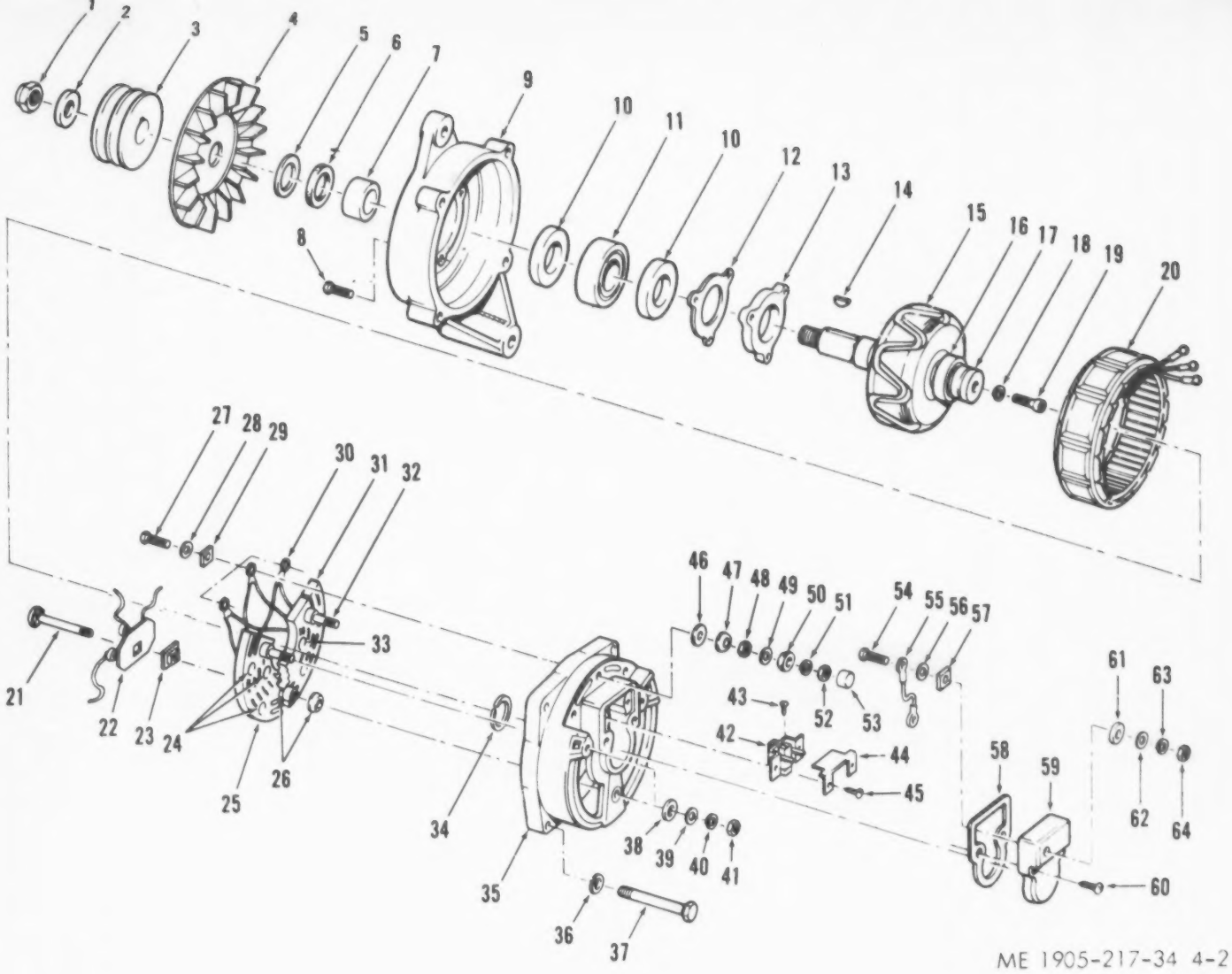


Figure 4-2. Alternator, explodea view (hulls 8540-8560 and 8580-8618).

(2) Remove locking nut (1) and washer (2) from the shaft.

(3) Pull the alternator from the pulley using a slight rocking motion to free the pulley.

(4) Remove fan (4) from shaft.

(5) Remove two self-tapping screws (60) and remove the rear cover (59) and cover gasket (58).

(6) Remove hex nut (64), lockwasher (63), flat washer (62), and insulator washer (61) from brush cover. Remove bolt (54), brush connecting lead (55), flat washer (56), and square insulator (57).

(7) Remove brush lead attaching screws (43). Retain cover plate lead.

(8) Remove self-tapping screws (45) securing brush and capacitor assembly (42, 44) and remove assembly.

(9) Remove through bolts (37) and lockwashers (33).

(10) Using wooden wedge and screwdriver, pry the front and rear sections apart. When apart, the rear section should contain the stator (20) and the front section should contain the rotor (15).

g. Disassembly of Rear Housing Assembly (Hulls 8540-8560 and 8580-8618).

(1) Separate the stator from the rear section by removing plastic caps (53), hex nuts (52), lockwashers (51), insulating washers (50), and flat washers (49) from the three AC terminals. Remove stator leads and pull the stator assembly from the rear section.

(2) Remove hex nuts (48), insulator washers (47), and flat washers (46) securing the alternator terminal stud. Remove RFI filter. Remove bolts (27), lockwashers (28), and insulator washers (29).

(3) Remove negative brush connector lead from negative rectifier heat sink (fig. 4-3).

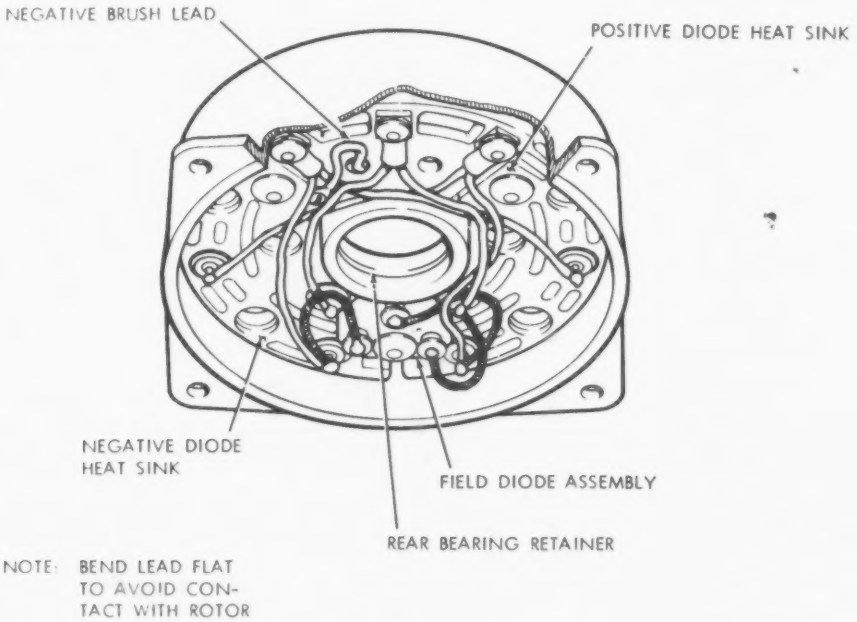

NEGATIVE BRUSH LEAD
POSITIVE DIODE HEAT SINK
NEGATIVE DIODE HEAT SINK
FIELD DIODE ASSEMBLY
REAR BEARING RETAINER
NOTE: BEND LEAD FLAT TO AVOID CONTACT WITH ROTOR
ME 1905-217-34/4-3

Figure 4-3. Diode installation (hulls 8540-8560 and 8580-8618).

(4) Remove hex nuts (41) and washers from bolts (21, 32).

(5) Carefully remove the negative heat sink (31) and the positive heat sink (25) from the rear section.

(6) Separate field diode assembly (22) from the positive and negative heat sinks by pulling bolts (21) from assembly observing location of molded washer (26) and square insulator (23). Separate heat sinks by removing harness assemblies (30) from bolts (32).

h. Disassembly of Front Housing Assembly (Hulls 8540-8560 and 8580-8618).

(1) Remove Woodruff key (14, fig. 4-2), flat washer (5), felt washer (6), and the pulley spacer (7).

(2) Remove the retaining screws (8).

(3) Press the rotor (15) from the front housing (9) using an arbor press.

(4) Remove the bearing seal (10) by placing a flat face punch through opening in the housing and tapping seal.

(5) Remove the front bearing (11) from the tor shaft with a bearing puller.

(6) Remove the grease seal (10), front bearing tainer gasket (12) and retainer (13) from the tor shaft.

(7) Remove the slip ring assembly (17) as llows:

NOTE

The slip ring assembly requires replacement only if the rings are worn or damaged beyond use of if the rear bearing is to be replaced.

(a) Remove cap screw (19) and lockwasher 8) from the end of the shaft.

(b) Unsolder two connections on the slip ng assembly using care not to damage the fiber asher between the rings or damage the wires.

(c) Slide slip ring assembly from end of haft.

(8) Remove rear bearing (16) from shaft with earing puller after removing the slip assembly. i. *Cleaning, Inspection, Repair and Testing Hulls 8500-8519 and 8520-8539*).

(1) Wipe grease seals with a clean cloth to emove foreign matter and lubricant.

CAUTION

Do not soak a grease seal in cleaning solvent to clean.

(2) Inspect seals for damage and replace if ecessary. Repack seals if necessary to 2/3 full ith a suitable ball bearing grease.

CAUTION

Do not overpack grease seals. Excess lubricant in alternator may flow into electrical parts and cause malfunction.

(3) Clean ball bearings in solvent (FED. SPEC. PD-680) to remove dirt and old lubricant. Do not spin ball bearings or use compressed air to dry bearings after cleaning. Allow bearings to air dry. Place a small quantity of grease on a clean flat surface. Press bearing into lubricant until grease starts to flow through to opposite side of bearing. Wipe off excess grease from sides and outside of bearings with a clean cloth.

CAUTION

Do not overpack ball bearings. Excess lubricant in alternator may flow into electrical parts and cause malfunction.

(4) Clean metal parts in approved cleaning solvent. Inspect parts for damage. Replace all defective parts.

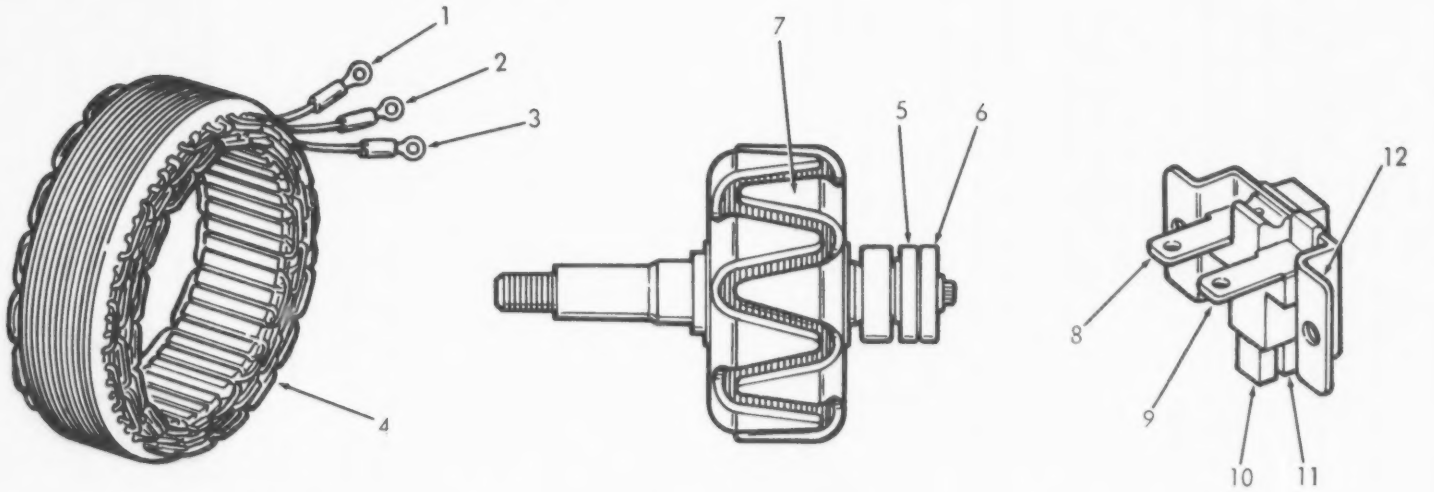
(5) Wipe off stator and rotor windings with a clean cloth.

CAUTION

Do not use compressed air hose on rotor or stator windings. Undetectable flaws may be created making assembly less than acceptable.

(6) Perform tests on electrical components using a suitable ohmmeter or multimeter.

(a) Check for short circuit between each stator lead and frame (fig. 4-4). Connect ohmmeter between each stator lead (1, 2, or 3) and stator frame (4) in turn. Ohmmeter should indicate open circuit or very high resistance. Stator assembly shall be replaced if winding(s) are shorted (no or low resistance).



STATOR ASSEMBLY

ROTOR ASSEMBLY

BRUSH ASSEMBLY

ME 1905-217-34/4-4

1. Stator lead
2. Stator lead
3. Stator lead
4. Stator frame
5. Rotor slip ring
6. Rotor slip ring
7. Rotor frame
8. Brush terminal
9. Brush terminal
10. Brush
11. Brush
12. Brush holder

Figure 4-4. Stator, rotor, and brush test points, Hulls 8500-8519 and 8520-8539.

(b) Check resistance between slip rings (E and F) (installed on rotor) with an ohmmeter (fig. 4-4). Resistance should be 14 to 18 ohms. If resistance is low, it indicates a short between windings. Very high resistance indicates an open winding. Replace defective rotor assembly.

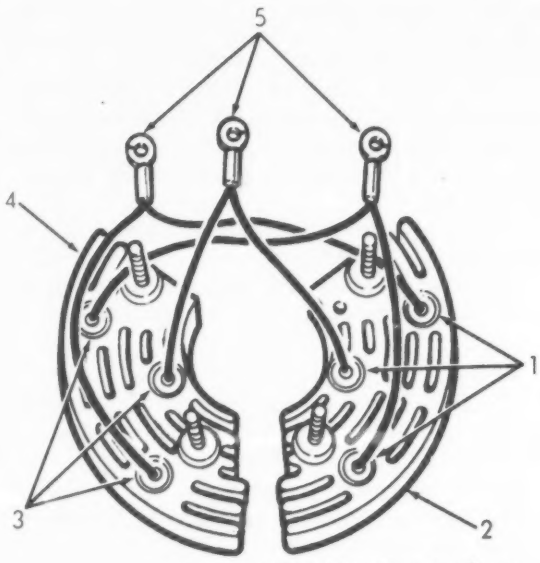
(c) Check resistance between each rotor slip ring (5 or 6) and rotor frame (7) with an ohmmeter. Resistance should be very high or indicate open circuit. If resistance is low, winding is shorted and rotor assembly must be replaced.

(d) Check resistance between brush terminals (8 and 9, fig. 4-4) and brush holder (12). Ohmmeter should indicate open circuit or very high resistance. If there is no or low resistance, replace brush assembly.

(e) Check resistance between brush terminal 8 and brush 10 (fig. 4-4). Ohmmeter should indicate very low resistance (near zero). If resistance is high, replace brush assembly. Perform same test between brush terminal 9 and brush 11.

(f) Check resistance of isolation diodes with ohmmeter. This can be done with diodes installed in heat sink. Disconnect lead wires and check each diode separately. Each diode should indicate a high resistance in one direction and low resistance in other direction (ohmmeter leads reversed). Replace defective isolation diode(s).

(g) Check negative rectifier diodes with an ohmmeter (fig. 4-5). Connect negative (—) ohmmeter probe to diode heat sink (2) and positive (+) probe to each diode (1) terminal. Resistance should be low or zero. If resistance is high, diode is defective.



1. Negative rectifier diode
2. Negative diode heat sink
3. Positive rectifier diode
4. Positive diode heat sink
5. Diode harness assembly

Figure 4-5. Rectifier diode test points (hulls 8500-8519 and 8520-8539).

(h) Check negative rectifier diodes as specified in (g) above but with ohmmeter leads reversed. Resistance should be high or infinite. If resistance is low, diode is defective.

(i) Check positive rectifier diodes with an

ohmmeter. Connect positive (+) probe to diode heat sink (4) and negative (−) probe to each diode (3) terminal. Resistance should be low or zero. If resistance is high, diode is defective.

(j) Check positive rectifier diodes as specified in (i) above but with ohmmeter leads reversed. Resistance should be high or infinitive. If resistance is low, diode is defective. Replace all faulty diodes.

j. Cleaning, Inspection, and Repair (Hulls 8540-8560 and 8580-8619).

(1) Wipe grease seals with a clean cloth to remove foreign material and old lubricant.

CAUTION

Do not soak grease seal in solvent.

(2) Inspect grease seals for damage. Repack seals 2/3 full of suitable ball bearing grease.

CAUTION

Do not overpack grease seals.

(3) Place ball bearings into solvent to remove dirt and old lubricant. Allow to air dry.

(4) Repack bearings with suitable grease ensuring that grease is forced out of opposite side.

CAUTION

Do not overpack ball bearings

(5) Clean metal parts in solvent, Inspect parts for damage.

(6) Inspect rear housing for damage. If bearing surface is severly damaged or worn in excess of 1.58 inch diameter, replace housing. Replace O-ring on rear bearing retainer (34, fig. 4-2).

(7) Inspect brush and capacitor assembly. Replace assembly if length of remaining brush is less than ¼ inch. Test capacitor with ohmmeter—should not show continuity after initial meter deflection. Clean assembly if brushes are not being replaced.

(8) Wipe off stator and rotor windings with a clean cloth.

CAUTION

Do not use compressed air to clean or dry rotor or stator windings.

k. Testing (Hulls 8540-8560 and 8580-8618).

(1) Using ohmmeter, check stator terminals A, B, and C (fig. 4-6) for continuity. Continuity should exist between terminals A and B, B and C, and A and C. Check for no continuity between the stator terminals and the stator laminations. Replace stator if correct indications are not received.

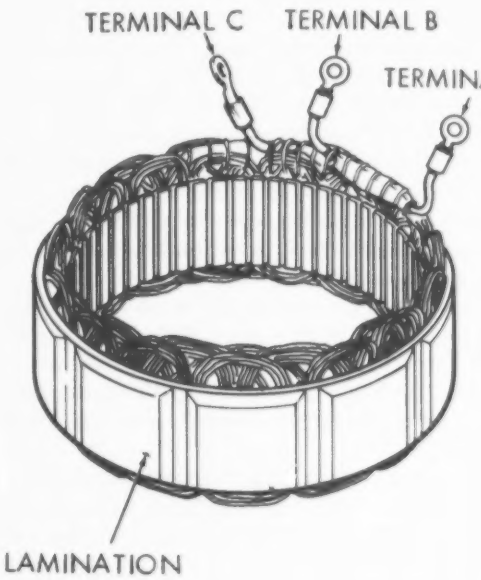


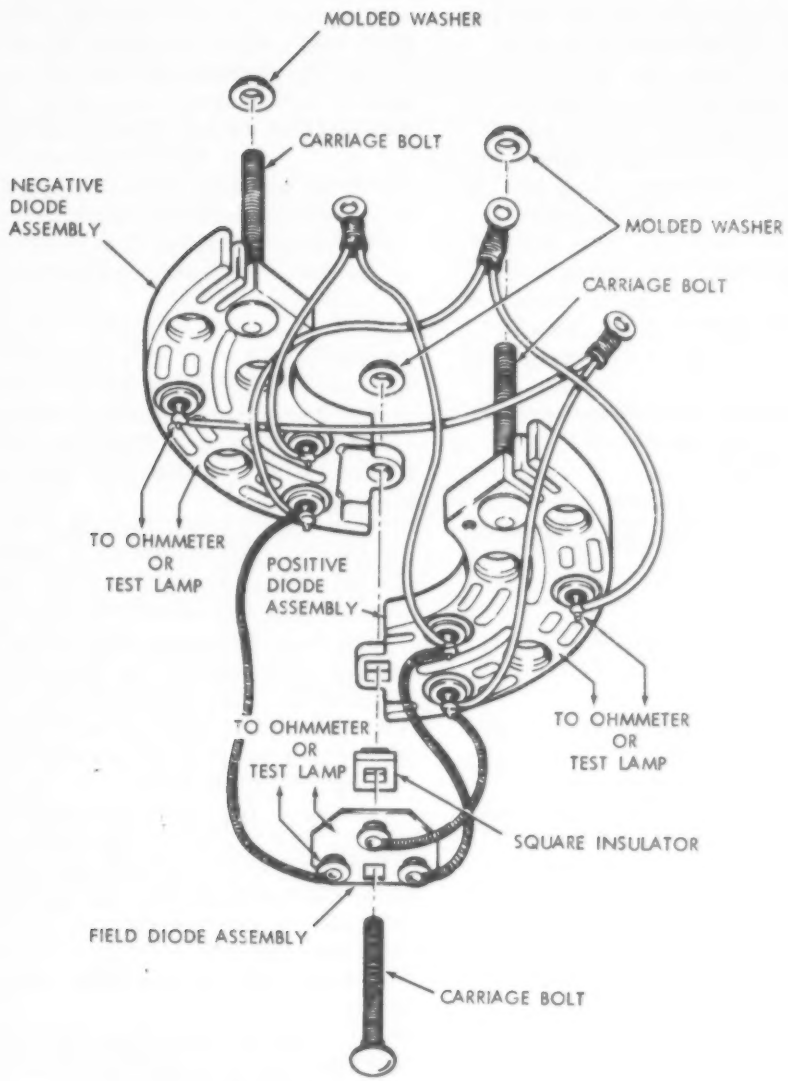
Figure 4-6. Alternator stator testing (hulls 8540-8560 and 8580-8618).

(2) Test rotor winding as follows:

(a) Measure resistance between slip rings. Resistance should be between 15.0 and 16.0 ohms. If resistance is low, a short is indicated between the windings. If the resistance is high, an open winding is indicated. In either case, the rotor must be replaced.

(b) Measure resistance between each rotor slip ring and the rotor shaft. The ohmmeter should indicate an open circuit or very high resistance. If no or low resistance is indicated, the winding is shorted and the rotor must be replaced.

(3) Test the field diode assembly as follows (refer to fig. 4-7):



ME 1905-217-34/4-7

Figure 4-7. Diode testing (hulls 8540-8560 and 8580-8618).

(a) Connect one ohmmeter or test lamp probe to field diode assembly plate and the other probe to each field diode in turn. The meter indication should be the same for each diode. If one diode results in a different meter indication, that diode is defective and the complete field diode assembly must be replaced.

(b) Reverse ohmmeter or test lamp leads and repeat step (a). The meter indication should be opposite to the indication obtained in step (a). Any deviation indicates a defective diode and the complete field diode assembly must be replaced.

(4) Test each diode in the positive heat sink as described in step (3a). All positive diodes should show conductivity from one DC polarity and no conduction when the polarity is reversed.

Test the negative rectifier diodes in a similar manner. Defective diodes in either the positive or negative heat sink can be removed as follows:

CAUTION

When applying soldering iron to a diode lead connection, grasp the diode connection terminal with long nose pliers (between diode and soldering iron) to prevent overheating and damage to the diode:

(a) Unsolder the connection wires to the diode.

(b) Set the diode plate on a 3/4 inch to 1 inch diameter tubular tool or jig with the terminal facing down.

(c) Use a small round tool and arbor press to press the diode from the heat sink.

CAUTION

Do not hammer diode to remove it.

l. Reassembly of Rotor and Front Housing Assembly (Hulls 8500-8519 and 8520-8539).

(1) Place the slip ring connecting wires in the groove of the rotor shaft.

(2) Press the rear ball bearings (16, fig. 4-1) onto the shaft applying pressure on the INNER race only.

(3) Place the slip rings (17) on the rotor shaft and draw them into place with the hex socket screw (19) using a new lock washer (18).

(4) Solder the two leads using resin core solder (Federal Specification QQ-S-571). Do not use excessive amounts of solder. (Leads are interchangeable).

(5) With an acceptable material such as red glyptal, cement the wires to the slip rings to prevent them from loosening.

(6) Press the seals (10) into front housing (9) and bearing retainer (13).

CAUTION

Apply pressure to the outer metal ring only. Otherwise permanent damage may result.

(7) Press the ball bearing (11) into the front housing (9).

CAUTION

Apply pressure on outer race only.

(8) With retainer gasket (12) in place, secure front bearing retainer (13) with three retainer screws (8).

(9) Press this front housing assembly onto the rotor shaft using an arbor press and suitable jig.

m. Reassembly of Rear Housing Assembly (Hulls 8500-8519 and 8520-8539).

(1) Install replacement diodes as follows: Fit new diode into round diode hole. Slowly rotate the diode in the hole until the serations on the diode are not lined up with the serations made in the hole by the original diode. This procedure insures good heat conduction and a secure mounting.

(2) Press diode into the hole with a ½ inch tubular tool making sure diode is completely seated. (Federal Specification QQ-S-571).

CAUTION

When soldering diodes, grasp the diode connection terminal with long nose pliers (between soldering iron and diode) to prevent overheating and possible damage to diode.

(3) Install diodes as necessary using procedures in (1) and (2) above. Be certain diode lead wires and harness are connected properly.

(4) Assemble carriage bolts (50 and 52, fig. 4-1), insulators (48 and 51) and terminal lug (49) on isolation diode assembly (46) and rectifier diode assemblies.

(5) Place the isolation diode assembly onto the two rectifier diode heat sink assemblies. Install washers (40, 41 and 42) on protruding carriage bolts and secure with acorn nuts (47).

(6) Place the entire diode assembly into rear housing (43). Secure the assemblies with the proper insulating washers (42), flat washers (41), lock washers (40) and hex nuts (39). Install the self-tapping screw to secure the ground lead to the negative diode plate.

(7) Place the stator assembly (20) into rear housing (43) and insert the carriage bolts (45), lock washers (38), and insulators (27). Secure the stator winding leads with the insulating washers (36), washers (23), lock washers (18) hex nuts (21) and stud caps (35).

n. Reassembly of Alternator (Hulls 8500-8519 and 8520-8539).

(1) Install bearing retainer (44, fig. 4-1). Carefully align front housing assembly with rotor and rear housing assembly. Press the housings together and install thru bolts (37) and lock washers (38). Tighten thru bolts to secure.

CAUTION

When replacing brush assembly, observe that the replacement is identical to the original since an error could cause serious damage to alternator.

(2) Place brush assembly (33) into rear housing (43) being certain brushes are set properly onto slip rings without chipping. Secure assembly and insulator (32) with two tapping screws (31).

(3) Secure internal field wire (29) and auxiliary wire to brush assembly terminals with two tapping screws (34).

(4) Assemble carriage bolt (30), internal field wire (29), washer (28), terminal insulator (27), to

rear cover (25) with washers (23 and 24), lockwasher (18), and hex nut (21).

(5) Secure the rear cover (25) and cover gasket (26) to the rear housing (43) with two tapping screws (22).

(6) Place pulley spacer (7) on shaft, then the felt washer (6) and flat washer (5).

(7) Place woodruff key (14) into key slot in rotor shaft. Position fan (4) on rotor shaft.

(8) Press pulley (3) over key onto rotor shaft. Install flat washer (2) on shaft and secure with self-locking nut (1).

(9) Check assembly of all parts, particularly electrical connections. Examine rotor assembly for freedom of movement; there should be no binding or contact between internal components.

(10) Perform in-vessel tests to determine that alternator is functioning properly (TM 55-1905-217-12, para 4-48).

o. Reassembly of Rotor and Front Housing Assembly (Hulls 8540-8560 and 8580-8618).

(1) Press rear bearing (16, fig. 4-2) to shoulder on rotor shaft applying pressure to bearing inner race only.

(2) Thread rotor winding leads through square hole in slip ring hub. Align square hole with slot on rotor shaft and press slip ring assembly in place.

(3) Secure assembly with cap screw (19) and lockwasher (18).

(4) Using ohmmeter, check resistance between each slip ring and rotor shaft. The meter should indicate open circuit or very high resistance.

(5) Solder rotor leads to slip ring terminals using resin core solder. The leads are interchangeable.

(6) Apply small amount of cement where rotor lead wires emerge from the slip ring hub.

(7) Using ohmmeter, measure resistance between slip rings. The meter should read 15.0 to 16.0 ohms resistance.

(8) Using ohmmeter, check for open circuit between each slip ring and the rotor shaft.

(9) Place front section housing, exterior side down on bed of arbor press. Press new seal (10) in housing with grease cavity up.

CAUTION

Press on outer edge only until seal bottoms in the housing.

(10) Install new seal (10) in the bearing retainer (13) with the grease cavity away from the retainer.

(11) Pack each seal cavity 2/3 full of bearing grease.

CAUTION

Do not overpack grease seals.

(12) Press the front bearing (11) into front housing (9).

CAUTION

Apply pressure to the bearing outer metal ring only.

(13) Put retainer gasket (12) and bearing retainer (13) in place and secure with retaining screws (8).

(14) Press front section housing with bearing in place onto the rotor shaft using arbor press.

CAUTION

Apply pressure on inner bearing race only. Insure that rotor leads will not interfere.

p. Reassembly of Rear Housing Assembly (Hulls 8540-8560 and 8580-8618).

NOTE

Refer to figure 4-7 for proper location and arrangement of rectifier components.

(1) Install replacement diodes as follows:

(a) Fit new diode (24) or (33, figure 4-2) into round diode hole.

(b) Rotate diode until serrations on the diode are not lined up with existing serrations in the hole.

(c) Press diode into hole with a ½ inch tubular tool making sure diode is completely seated.

(d) Solder diode connecting leads using resin core solder.

CAUTION

When soldering diodes, grasp the diode connector terminal with long nose pliers (between soldering iron and diode) to prevent overheating diode.

(2) Install carriage bolt (21) in field diode assembly (22) and place square insulator (23) on bolt.

(3) Assemble field diode assembly to the positive heat sink (25) ensuring that the square indicator separates the assembly and the heat sink.

(4) Assemble negative heat sink (31) to positive heat sink insuring that the molded washer (26) separates the two heat sinks.

(5) Place molded washers (26), with shoulder facing away from diode assembly, on bolts (21) and (32). Place diode assembly into rear housing.

(6) Place insulator washers (38), flat washers (39), lockwashers (40), and hex nuts (41) on protruding carriage bolts (21) and (32). Tighten nuts evenly to avoid breaking insulator washers.

(7) Install negative brush lead to negative diode plate. Position lead so it does not strike rotor.

(8) Install flat washers (28), square in-

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sulators (29), and diode harness (30) on bolts (27) and insert through rear housing.

(9) Install RFI filter and secure carriage bolts with flat washers (26), insulator washers (47), and hex nuts (48). Tighten nuts evenly to avoid breaking insulating washers.

(10) Place stator assembly (20) into rear housing and connect stator leads to carriage bolts (27). Secure stator leads with flat washer (49), insulator washers (50), lockwasher (51) hex nuts (52), and plastic caps (53). Tighten nuts evenly to avoid breaking insulating washers.

q. Reassembly of Alternator (Hulls 8540-8560 and 8580-8619).

(1) Install rear bearing retainer (34, fig. 4-2). Lubricate retainer lightly with oil.

(2) Aline front and rear sections and hand press the sections together.

(3) Install through bolts (37) and lockwashers (36). Tighten through bolts (37) and lockwashers (36). Tighten through bolts evenly to 45-53 inch pounds.

(4) Place brush and capacitor assembly (42, 44) into rear housing insuring brushes are set properly on slip rings. Secure assembly with self-tapping screws (45).

(5) Secure brush connecting cable (55) to brush terminal with lead attach screws (43). Secure negative brush lead to brush terminal with screw (43).

(6) Assemble carriage bolt (54), cover plate cable (55), flat washer (56) and square insulator (57) to felt gasket (58) and rear cover (59). Secure bolt with insulator washer (61), flat washer (62), lockwasher (63), and hex nut (64).

(7) Secure rear cover and gasket to the rear housing with self-tapping screws (60).

(8) Place pulley spacer (7), felt washer (6) and flat washer (5) on rotor shaft.

(9) Place Woodruff key (14) and fan (4) on rotor shaft.

(10) Press pulley (3) over key onto rotor shaft and secure with steel washer (2) and locking nut (1). Tighten nut to 50-60 foot pounds.

(11) Spin rotor by hand to verify freedom of rotor and bearings.

(12) Perform in-vessel tests (TM 55-1905-217-12, para. 4-48).

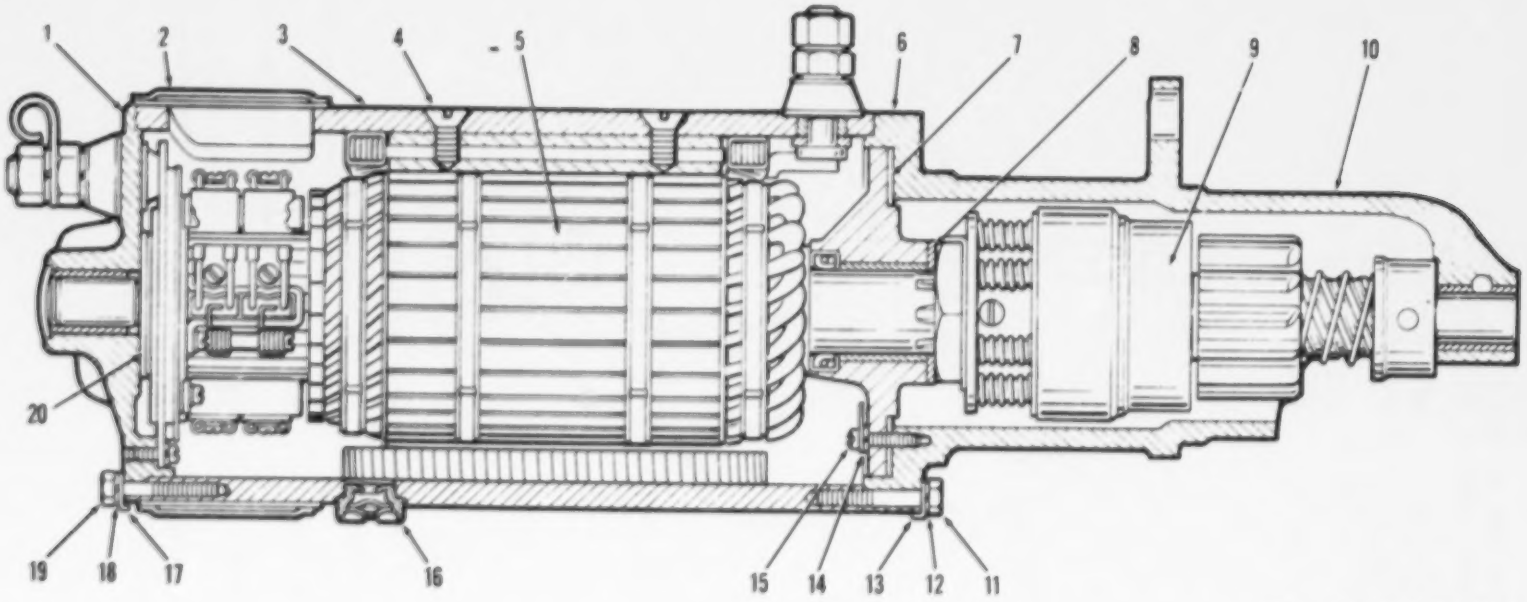
r. Installation. Install the alternator (TM 55-1905-217-12, para 4-48).

4-3. Electric Starter Motor

a. Removal. Remove the starter motor (TM 55-1905-217-12, para 4-50).

b. Disassembly into Subassemblies. Disassemble the starting motor into major components as follows:

(1) Loosen two cover band bolts and slide cover band assembly (2, fig. 4-8) from frame and field assembly (3).



ME 1905-217-34/4-8

1. Commutator end bearing assembly
2. Cover ban assembly
3. Frame and field assembly
4. Pole shoe screw
5. Armature assembly
6. Middle bearing assembly
7. Gasket
8. Spacer washer
9. Bendix drive assembly
10. Drive housing assembly
11. Drive housing bolts
12. Flat washers
13. Lockwasher
14. Lockwasher
15. Machine screw
16. Ventilator
17. Lockwasher
18. Flat washer
19. End bracket bolts
20. Brake shoe

Figure 4-8. Starter motor—cross-section view.

NOTE

Do not disassemble the cover band assembly.

(2) Remove four commutator end bracket bolts (19) from commutator end bearing assembly (1).

(3) Tap end bearing assembly (1) with a rawhide mallet to loosen and remove this assembly from frame and field assembly (3).

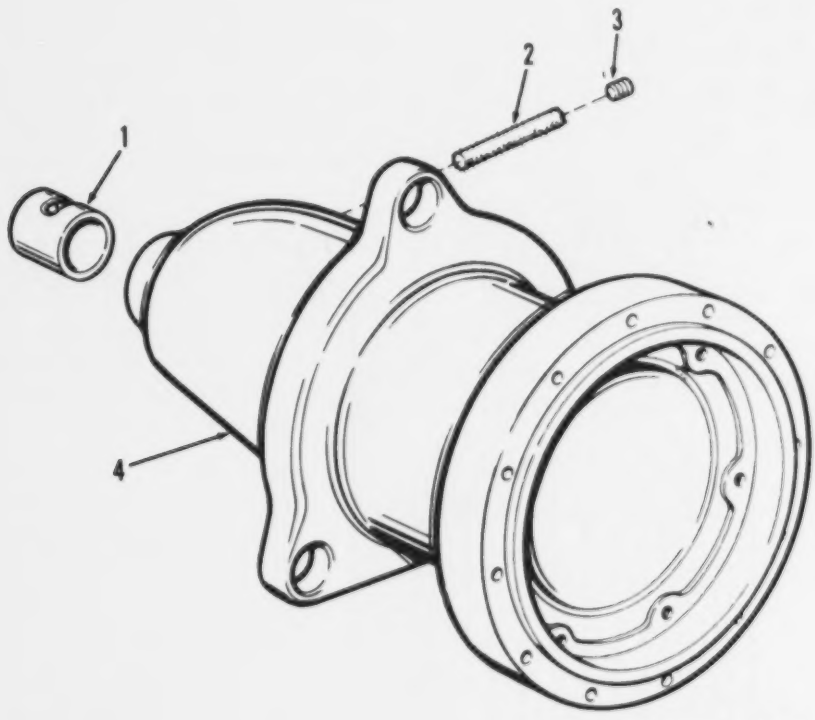
(4) Remove twelve drive housing bolts (11) holding frame and field assembly (3) to motor drive housing assembly (10) and remove frame and field assembly.

c. Disassembly of Drive Housing Assembly. To disassemble the drive housing, it must be removed from middle bearing assembly (6, fig. 4-8) and Bendix drive assembly (9) as follows:

(1) Remove locking wire and remove six middle bearing attaching screws (15) which secure middle bearing assembly (6) to drive housing assembly (10).

(2) Remove middle bearing assembly (6) with Bendix drive assembly (9) and armature assembly (5) from drive housing assembly (10).

(3) Remove drive end pipe plug (3, fig. 4-9) and drive end lubricating wick (2) from housing (4).



ME 1905-217-34/4-9

1. Sleeve bearing
2. Lubricating wick
3. Pipe plug
4. Drive housing

Figure 4-9. Motor drive housing—exploded view.

(4) The drive end housing sleeve bearing (1) may now be pressed from the housing. Use suitable arbor press and rod for this purpose.

NOTE

Do not remove the bearing unless replacement is necessary.

d. Disassembly of Middle Bearing Assembly.

(1) Remove middle bearing gasket (7, fig. 4-8).

(2) Move retaining wire to one side and loosen setscrew holding Bendix drive assembly (9) to armature assembly (5).

(3) Pull Bendix drive assembly (9) from armature assembly.

(4) Remove middle bearing assembly (6), spacer washer (8) and brake shoe (20) from armature shaft.

(5) Remove oil hole plug (1, fig. 4-10).

(6) Remove lubricating wick (2).

(7) Remove pipe plug (4).

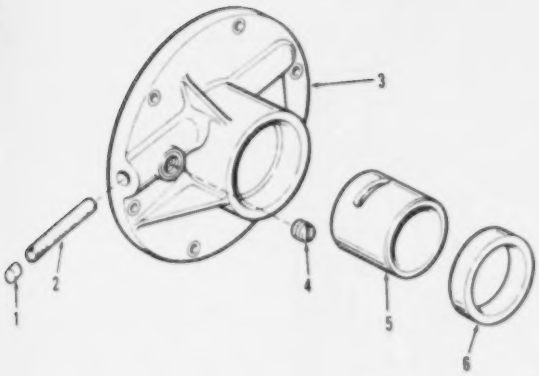
(8) Press middle sleeve bearing (5) and oil seal (6) from middle bearing bracket (3). Use a suitable rod and arbor press for this purpose.

NOTE

Do not remove bearing and seal unless replacement is necessary.

e. Disassembly of Commutator End Bearing Assembly.

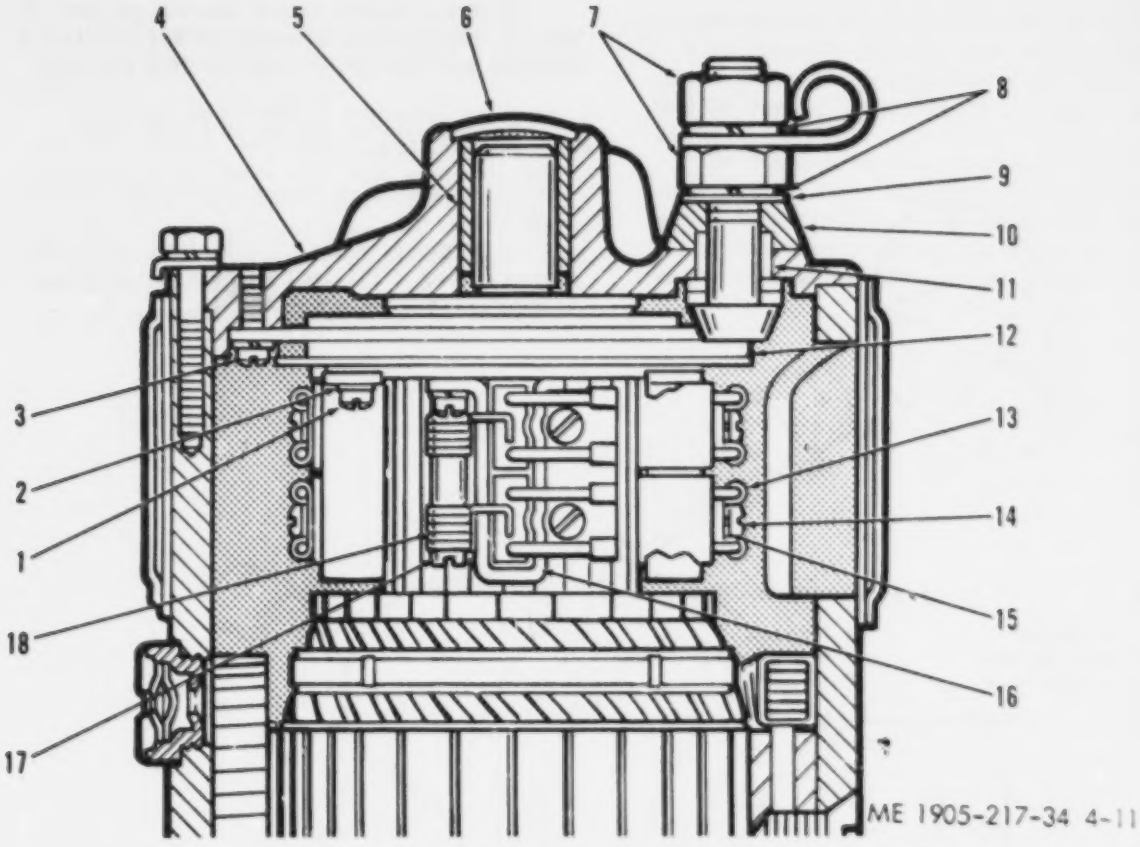
(1) Remove eight brush lead attaching screws (14, fig. 4-11), lock washers (15) and brush assemblies (13).



ME 1905-217-34/4-10

1. Oil hole plug
2. Lubricating wick
3. Bearing bracket
4. Pipe plug
5. Sleeve bearing
6. Oil seal

Figure 4-10. Middle bearing assembly—exploded view.



1. Brush holder screw
2. Lock washer
3. Brush plate holder screw
4. End bracket
5. Sleeve bearing
6. Expansion plug
7. Terminal stud nut
8. Lockwasher
9. Flat washer
10. Terminal stud insulator
11. Terminal stud bushing
12. Brush and stud plate
13. Brush assembly
14. Brush lead screw
15. Lockwasher
16. Brush holder
17. Brush holder pin
18. Brush spring

Figure 4-11. Commutator end bearing assembly—cross-section view.

(2) Two of the brush holders may be removed in the following manner:

(a) Remove brush holder screws (1), lockwashers (2), brush holder pins (17) and brush springs (18).

(b) Remove brush holders (16) and brush holder spacer plates from brush and stud plate (12).

(3) The other two brush holders may be removed in the following manner:

(a) Remove brush holder screws (3) and lockwashers, brush holder pins (17) and brush springs (18).

(b) Remove brush holders (16) and brush holder spacer plates from brush and stud plate (12).

(4) Remove terminal stud nuts (7), lockwashers (8), plain washer (9), terminal stud insulator (10), and insulated terminal stud bushing (11) as required.

(5) Remove brush plate assembly from commutator end bracket (4).

(6) If necessary, brush and stud plate (12) may be separated from the brush plate in order to replace defective parts.

(7) To replace commutator end bearing (5), remove commutator end expansion plug (6) and commutator end pipe plug and wick. Press sleeve bearing (5) from bracket (4).

NOTE

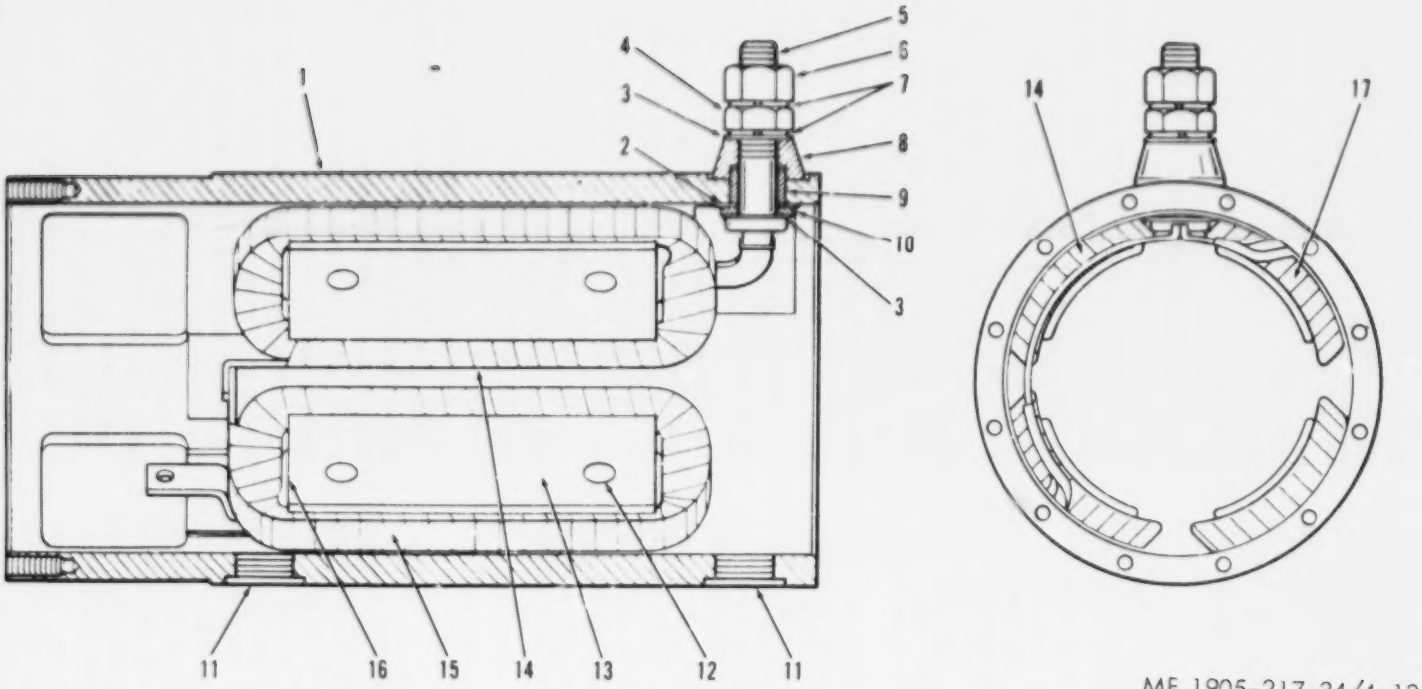
Do not remove plug (6) or bearing (5) unless replacement is necessary.

f. Disassembly of Frame and Field Assembly.

NOTE

Do not remove pole shoes or field coil assemblies unless defective parts make disassembly necessary.

(1) Unsolder field coil assembly leads from field terminal studs (5, fig. 4-12).



1. Field frame
2. Insulation strip
3. Flat washer
4. Terminal stud nut
5. Terminal stud
6. Terminal stud nut
7. Lock washer
8. Terminal stud insulator
9. Terminal stud bushing
10. Flat washer
11. Ventilator
12. Pole shoe screw
13. Pole shoe
14. Field coil
15. Insulation strip
16. Insulation strip
17. Field coil

Figure 4-12. Frame and field assembly—cross-section view.

(2) Remove eight pole shoe screws (12), four pole shoes (13) and two field coil assemblies (14 and 17) from the field frame (1).

(3) Remove field coil insulating strips (15 and 16).

(4) Remove two ventilators (11).

(5) If necessary, remove terminal stud nut (6), terminal stud lock washer (7), terminal stud nut (4), lockwasher (7), washer (3), stud insulator (8), insulated stud bushing (9) from the field terminal stud (5).

(6) Remove field terminal stud (5) from frame (1) and remove washer (3) and inside insulator washer (10) from stud.

g. Cleaning.

(1) Use inhibited methyl chloroform to remove dirt and grease from all parts except the armature and fields.

NOTE

Refer to BuShips Instructions 6260.5 SER 360-50513 dated 7 October 1958 and change No. 1, SER 660-4980 dated 19 January 1959 for characteristics, toxicity, flammability effect on material and application of inhibited methyl chloroform.

(2) Do not clean the armature by any degreasing method since this would damage insulation and thereby possibly ruin the armature. To clean, wipe with a clean cloth slightly dampened with inhibited methyl chloroform.

(3) General cleaning of the commutator is done with No. 0/2 flintpaper (Federal Specification P-P-111). If the commutator is worn, out-of-round by more than 0.003 inch, has high mica, filled slot, or is burned, mount the armature by the shaft bearing surfaces in a lathe and take light cuts until the commutator is completely cleaned up.

NOTE

Make cut not deeper than necessary.

(a) Undercut mica 1/32 inch.

(b) Remove all burrs with 0/2 flintpaper.

(4) The field coils should not be cleaned by any degreasing method, since this would damage the insulation and might ruin the windings. Clean by wiping with a clean, dry cloth. Be careful in handling the windings to avoid breaking or weakening the connecting straps between windings. If the field insulation is charred or chafed so that the windings are exposed, it is sometimes possible to rewrap them with insulating tape (0.007 x ½ glass tape-Specification Mil-I-3158) and paint them with insulating varnish (Specification Mil-V-1137 grade CB). This operation must be executed with care and neatness since excessive bulkiness of the tape will prevent reassembling the windings under the pole shoes in the proper manner. Soldered connections must be made with rosin core solder (Federal Specification QQ-S-571).

h. Inspection and Repair.

(1) Brushes. If the brushes are worn down to 5/16 inch (original length ½ inch), replace brushes. Make sure that the pigtail leads are tight in the brushes and that the clips are fastened securely to the leads.

(2) Brush springs. The brush springs should have sufficient tension to provide the proper pressure between the brushes and commutator after the unit is assembled. This may be checked by placing the armature and commutator end frame together in their normal operating position and then placing the brushes in their holders with the springs in place so that the tension of the springs against the brushes can be measured with a spring gauge. Correct spring tension should be 36 to 40 ounces. Replace springs if tension is not correct.

(3) Sleeve bearings. If the bearings are worn more than 0.005 inch beyond maximum dimension, as listed below, they should be replaced. Wear will be greatest on the side which sustains the greatest thrust during cranking. After a new bearing is pressed into place, cross drill oil hole. Ream to finish size, as listed below, and remove burrs in oil passage. Finish size of bearings are:

Drive end housing bearing, ID	0.8145	0.8165	inch
Middle bearing, ID	0.997	0.999	inch
Commutator end bearing, ID	0.562	0.564	inch

(4) Brush holders and parts. If the brush holders, spacer plates, insulators, etc., are bent, warped, cracked, burned, or otherwise damaged, replace parts as needed.

(5) Bendix drive assembly. The spring clutch Bendix drive assembly is serviced by replacing complete unit. The unit must be in good condition, with parts tightly fastened together. If pinion teeth are worn, burred, or chipped, replace Bendix drive assembly.

(6) Miscellaneous parts. Any defective insulator, screw, washer, lead, stud, plate, etc., should be replaced. Cracked, bent, worn, burned insulators or washers are defective. Studs or screws which are bent, battered, broken, or which have crossed or damaged threads, are defective. Leads which have broken strands or frayed insulation are defective.

i. Testing.

(1) *Armature.*

(a) *Ground.* The armature leads may become grounded to the armature laminations

due to deterioration of the insulation. This can be checked with a 110 volt test lamp and test points, checking from the commutator to the armature laminations. If the lamp lights, a ground exists, and the armature must be replaced.

(b) *Open.* The armature may become open circuited at the commutator riser bars as a result of long cranking periods, which overheat the unit and cause the armature leads to become open circuited. An open circuited armature is often easy to detect, since this condition produces some badly burned commutator bars with other bars fairly clean. Since the armature is of a welded construction such a condition will be rare, but if it does occur, replace the armature.

(c) *Short.* A short circuit may occur between adjacent armature leads due to deterioration of the insulation. To check an armature for short circuits, place armature on a growler and hold a thin steel strip lengthwise on the core parallel to the shaft. Slowly rotate the armature through a complete revolution. If a short circuit is present, the steel strip will become magnetized and vibrate. Inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars. If short circuit still exists, replace armature.

(2) *Field coils.*

(a) *Ground.* The fields may become grounded to the frame due to deterioration of the insulation. This can be checked with a 110 volt test lamp and test points, checking from the field coil terminals to the frame. If the lamp lights, a ground exists, and the defective field coil must be replaced.

(b) *Open.* An open circuited field coil can be checked with a test lamp and test points, checking the two extremities of each field coil. If the test lamp fails to light, an open circuit exists and the defective field coil must be replaced.

j. Reassembly of Frame and Field Assembly.

(1) Place washer (3, figure 4-12), and inside flat insulation washer (10) on field terminal stud (5) and insert into frame (1).

(2) In order, place these items onto the field terminal stud (5): insulated stud bushing (9), stud insulator (8), washer (3), lockwasher (7), terminal stud nut (4), lock washer (7) and terminal stud nut (6).

(3) Insert two ventilators (11).

(4) Put into place the two pieces of field coil insulation strip (15) and the field coil insulating strip (16).

(5) Position in the frame two field coil assemblies (14 and 17) and four pole shoes (13). Secure with eight pole shoe screws (12).

(6) Solder the field coil leads onto the field terminal stud (5).

k. Reassembly of Commutator End Bearing Assembly.

(1) Install and ream sleeve bearing (5, fig. 4-11) per paragraph 4-3h(3) above. Install expansion plug (6) and lubricating wick. Apply 8 to 10 drops of engine oil OE-10 (Specification MIL-L-2104) to wick.

(2) Attach the brush screw support plate with the brush and stud plate (12) with the three brush plate attaching screws, lock washers and plain washers.

(3) Install this brush plate assembly into the commutator end bracket (4).

(4) Install the following in the order presented: insulated terminal stud bushing (11), terminal stud insulator (10), flat washer (9), terminal stud lockwasher (8), terminal stud nut (7), terminal stud lockwasher (8) and terminal stud nut (7).

(5) Two brush holders may be installed as follows:

(a) Place the brush holders (16) and brush holder spacer plates onto the brush and stud plate (12).

(b) Insert the brush springs (18), brush holder pins (17) and the lockwashers and brush holder screws (3).

(6) The other two brush holders may be installed as follows:

(a) Place the brush holders (16) and brush holder spacer plates onto the brush and stud plate (12).

(b) Insert the brush springs (18), brush holder pins (17) and the lockwashers (2) and brush holder screws (1).

l. Reassembly of Middle Bearing Assembly.

(1) Install new sleeve bearing (5, fig. 4-10) into bracket (3) per paragraph 4-3h(3) above.

(2) Press a new seal (6) into the bearing bracket.

(3) Install pipe plug (4), lubricating wick (2) and oil hole plug (1). Apply 8 to 10 drops of engine oil OE-10 (Specifications MIL-L-2104) to wick.

m. Reassembly of Drive Housing Assembly.

(1) Install new sleeve bearing (1, fig. 4-9) in drive housing (4) per paragraph 4-3h(3) above.

(2) Install the drive end lubricating wick (2), place 8 to 10 drops of engine oil OE-10 (Specification MIL-L-2104) in the reservoir and secure the passage with the pipe plug (3).

n. Reassembly of Starting Motor.

NOTE

Apply light coat of engine oil OE-10 (Specification MIL-L-2104) to inside of all sleeve bearings prior to final assembly.

(1) Position the commutator end bearing assembly (1, fig. 4-8) to the frame and field assembly (3) and secure with the six attaching screws (19), plain washers (18) and lockwashers (17).

(2) Place the spacer washer (8) and the middle bearing assembly (6) on the shaft of the armature assembly (5).

(3) Press the Bendix drive assembly (9) on the armature shaft and secure by tightening the setscrew; then slide the retaining wire into place.

(4) Position a new middle bearing gasket (7) on the motor drive housing assembly (10) and place over the Bendix drive assembly. Secure to the middle bearing assembly with six screws (15) and lockwashers (14). Secure screws (15) with a locking wire.

(5) Place the brake shoe (20) on the armature shaft (brush end) and insert the armature assembly (5) in the frame and field assembly (3).

(6) Secure these subassemblies to the frame and field assembly with twelve bolts (11), flat washers (12) and lockwashers (13).

(7) Install eight brush assemblies (13, fig. 4-11.

(8) Position the two field coil leads to the proper brush assemblies and secure the brushes with the eight brush lead attaching screws (14, fig. 4-11) and lockwashers (15).

(9) Slide cover band assembly (2, fig. 4-8) into position and secure by tightening the two cover band bolts.

o. Test After Overhaul. Before any testing, perform thorough inspection of starting motor for proper assembly, particularly electrical connections. Be sure sleeve bearings wicks and reservoirs have been lubricated.

(1) *No-load test.* Connect the starting motor in series with four 6 volt 200 amp storage batteries, a suitable variable resistor to control voltage, and an ammeter capable of reading several hundred amperes. If an rpm indicator is available, read the armature rpm as well as the current draw with the unit running free speed or no-load. The starting motor should meet the following specification:

Maximum current	90 amperes
Voltage	23.3 vdc
Rpm (approx)	8500

(2) *Torque test.* Torque testing equipment is required for conducting a stall torque test of the starting motor. The torque developed, current drawn, and voltage are checked together. The starting motor should meet the following specifications:

Maximum current	500 amperes
Voltage	3.2
Minimum torque	22 lb ft

f. Installation. Install the starter motor. (TM 55-1905-217-12, para 4-50).

Section II. HYDRAULIC STARTING SYSTEM

4-4. General

A description of the hydraulic starting system is included in the Operator and Organizational Maintenance Manual TM 55-1905-217-12.

4-5. Hydraulic Starting System Reservoirs

a. General. The reservoirs are mounted on the starboard side of the engine room as shown in figures 4-13 and 4-14.

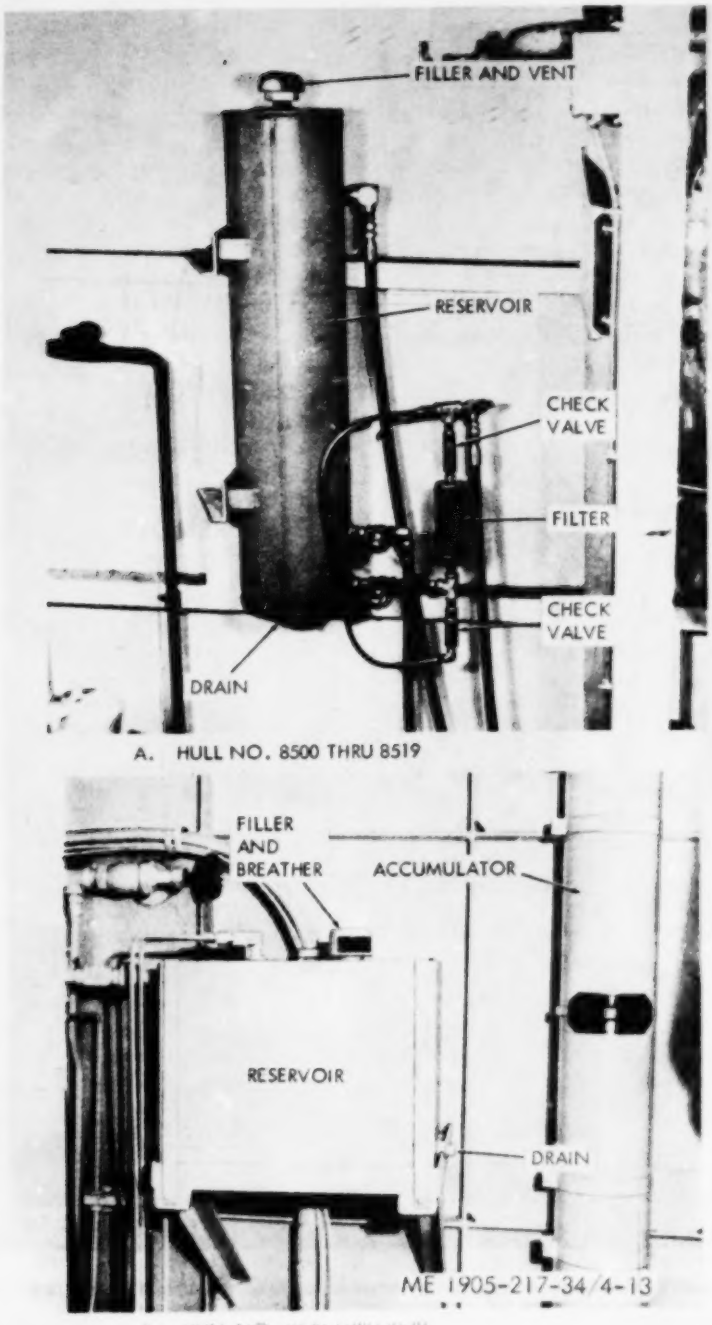


Figure 4-13. Hydraulic starting system reservoirs (hulls 8500-8519 and 8520-8539).

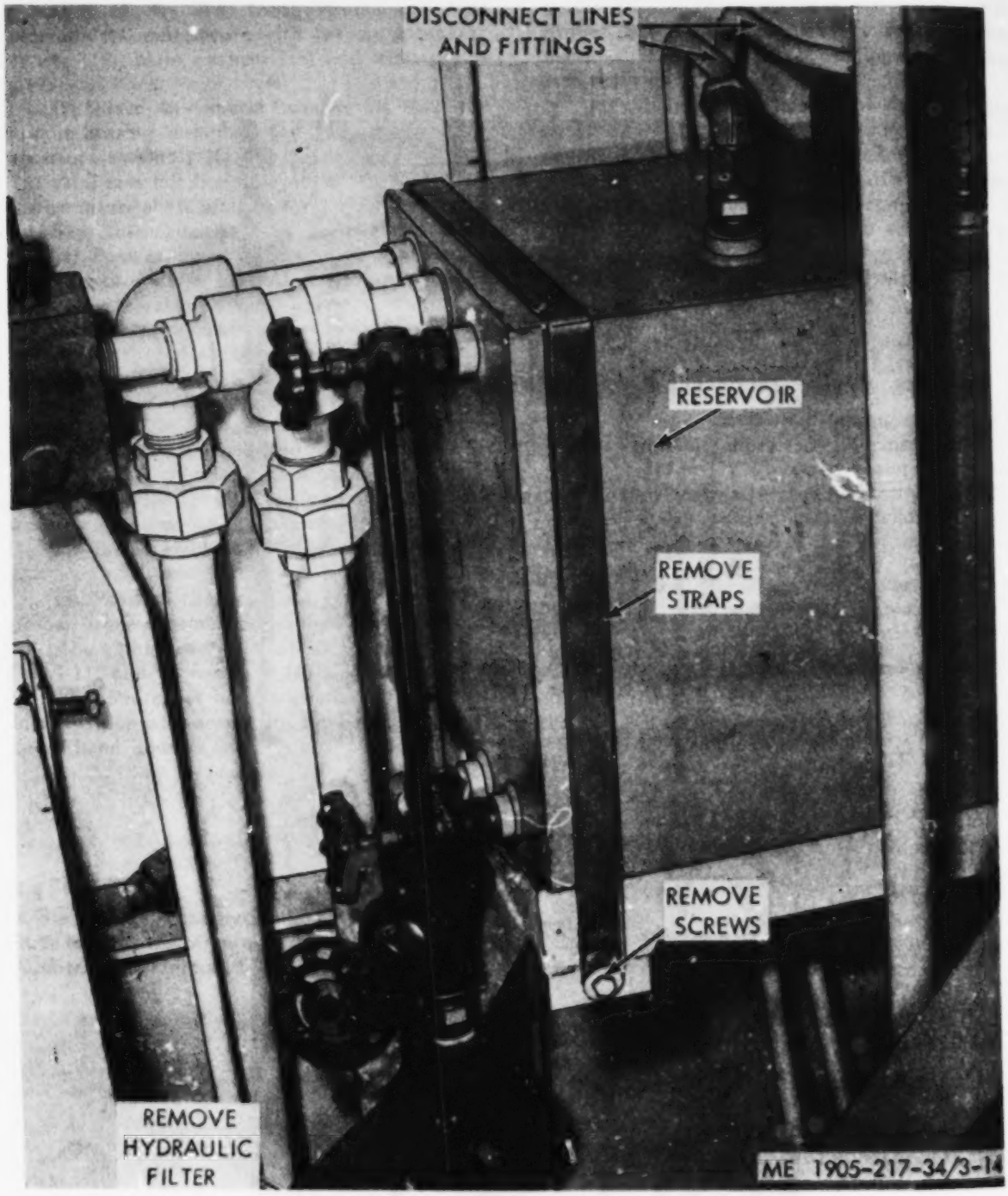


Figure 4-14. Hydraulic starting system reservoir (hulls 8540-8560 and 8580-8618).

b. Removal and Disassembly.

(1) Remove the hydraulic filter, sight gage, hose fittings and valves, lines, and fittings (TM 55-1905-217-12, para 4-59).

(2) Remove the mounting bolts (1, fig. 4-15), and washers (2) and remove the mounting brackets (3) and reservoir (4).

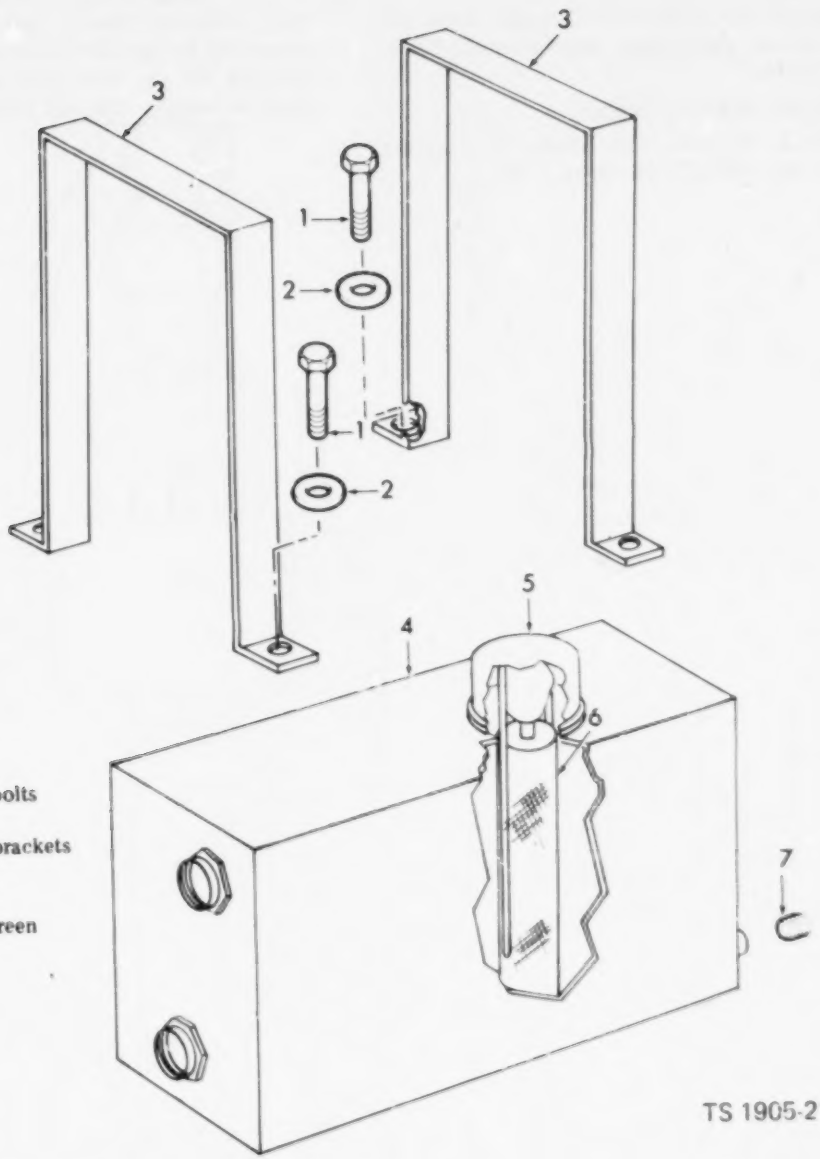


Figure 4-15. Hydraulic oil reservoir, removal, disassembly, reassembly, and installation.

(3) Remove the breather (5), strainer screen (6), and plug (7).

c. Cleaning, Inspection, and Repair.

(1) Clean all parts of the hydraulic oil reservoir with cleaning solvent (FED. SPEC. PD-680) and dry thoroughly.

(2) Inspect all parts for cracks, corrosion, dents, and defective or missing hardware.

(3) Straighten dents; weld minor cracks and breaks.

WARNING

Be sure tank is filled with sand or water before attempting any welding.

(4) Replace defective parts as necessary.

(5) Replace a hydraulic oil reservoir that is damaged beyond repair.

d. Reassembly and Installation.

(1) Install the plug (7, fig. 4-15), strainer screen (6), and breather (5).

(2) Install the reservoir (4) with the brackets (3), lockwashers (2) and bolts (1).

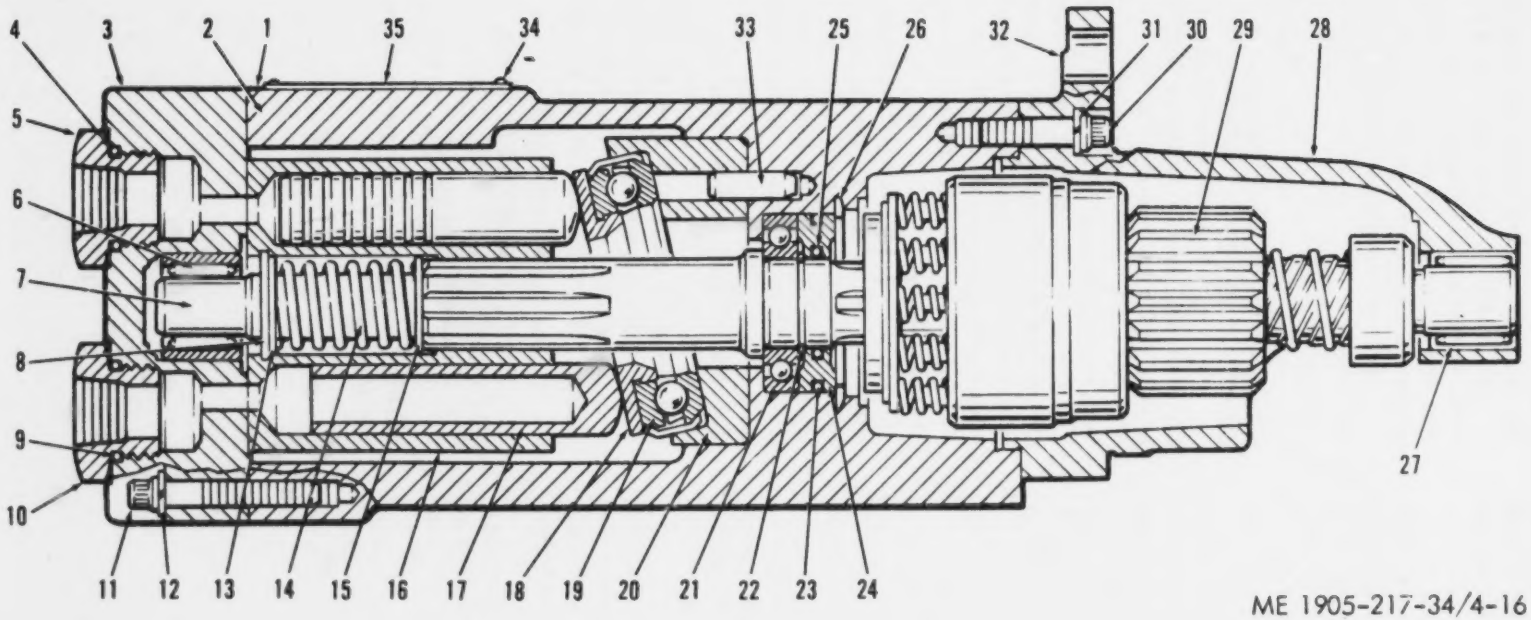
(3) Install the lines and fittings, hose fittings and valves, sight gage, and hydraulic filter, paragraph 4-58.

4-6. Hydraulic Starting Motor

a. Removal. Remove the hydraulic starting motor (TM 55-1905-217-12, para 4-63).

b. Disassembly.

(1) Clamp motor housing (2, fig. 4-16) in a vise. Remove pinion gear housing (28) and mounting flange (32) which are fastened to motor housing (2) by four screws (30). Slide Bendix drive assembly (29) off shaft (7).



ME 1905-217-34/4-16

1. Hydraulic motor assembly
2. Housing assembly
3. Port plate
4. Gasket
5. Adapter fitting
6. Roller bearing
7. Drive shaft
8. Retaining ring
9. Gasket
10. Adapter fitting
11. Cap screw
12. Lockwasher
13. Washer
14. Spring
15. Washer
16. Cranking motor barrel
17. Cranking motor piston
18. Thrust bearing plate
19. Special ball thrust bearing
20. Thrust bearing housing
21. Ball bearing
22. Retaining ring
23. Outer seal
24. Holder, sealing rings
25. Inner seal
26. Retainer ring
27. Needle bearing
28. Pinion gear housing
29. Bendix drive assembly
30. Screw
31. Lock washer
32. Flange
33. Dowel pin
34. Screw
35. Name plate

Figure 4-16. Hydraulic starting motor—cross section view.

(2) Before removing port plate (3) put indexing mark on the port plate (3) and motor housing (2) to enable proper positioning of port plate (3) at reassembly.

(3) Remove port plate cap screws (11) and lockwashers that hold port plate (3) to housing assembly (2). There is a slight spring load on this plate and upon loosening the screws, any oil left in housing will drain out. Remove port plate (3). Remove motor barrel assembly (16 and 17) by turning housing upside down and allowing the barrel and pistons (16 and 17) to slide off spline of shaft (7). Remove pistons (17) from barrel (16).

(4) Remove retainer ring (26). Press shaft (7) out of housing from port plate end. The seals (23 and 25), seal holder (24) and shaft bearing (21) will come out with shaft (7).

(5) To remove thrust bearing (19), press against thrust bearing housing (20) with a little pressure and the bearing housing with thrust bearing assembly will come out of port plate end as an assembly. Remove thrust bearing plate (18). To remove thrust bearing (19) from thrust bearing housing (20), apply heat to housing and press out thrust bearing (19).

CAUTION

DO NOT apply excessive heat. DO NOT remove thrust bearing (19) unless it is to be replaced.

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent (FED. SPEC. PD-680), and dry thoroughly.

(2) Clean all passages with compressed air.

(3) Pinion gear housing (28). Visually check housing for cracks or other damage. Examine bearing (27) for damage or wear. Replace, if necessary.

(4) Drive assembly (29). Examine pinion gear to be sure that the teeth are not worn excessively or chipped from interference with ring gear. Check to insure that the compressing spring are not damaged or broken.

(5) Port plate assembly (3). The port plate face, where cylinder rides, must be smooth and free of scoring. Also check the bearing (6) and replace if necessary.

(6) Motor barrel (16). Examine the potted face of the cylinder for scratching or scoring. Slight scuff marks can be removed by lapping on a surface plate. The bores of the cylinder (16) should be smooth and free of scoring.

(7) Pistons (17). The diameter of the pistons (17) should be smooth and free of scoring. The closed end of the pistons may show brinnelling where they contact the thrust bearing plate (18), but no burrs or flat spots are permissible.

(8) Shaft (7). Check the ends of the shaft for wear or scoring. The splines should be smooth and free of nicks. Check the bearing (21) and replace if necessary.

(9) Seal assembly (24). Replace the seals (23 and 25).

d. Reassembly.

(1) Be sure all parts are clean and free of burrs before starting reassembly. Use clean light oil to lubricate parts before assembly.

(2) Install the ball bearing (21, figure 4-16) on shaft (7). Install retaining ring (22). Press shaft (7) with ball bearing (21) and retaining ring (22) into the housing (2). Install seal holder (24) with seals on shaft (7). Install retaining ring (26).

(3) Install thrust bearing housing (20) with thrust bearing (19) into housing (2) with slight pressure. Press it until it has bottomed against housing (2). Be sure dowel pin (33) is in place. Install thrust bearing plate (18) into thrust bearing (19).

(4) Install the barrel (16) with pistons (17) on shaft (7). Be sure that the spring (14) in the cylinder is in place. Assemble the port plate (3) to the housing (2). To insure best alinement between the port plate and the motor housing, put the pinion housing (28) on the motor before tightening the cap screws (11). Torque screws (11) to 300 in-lbs. There should be slight precompression of the barrel (16) with the port plate (3). If not, replace spring (14) in the cylinder (16).

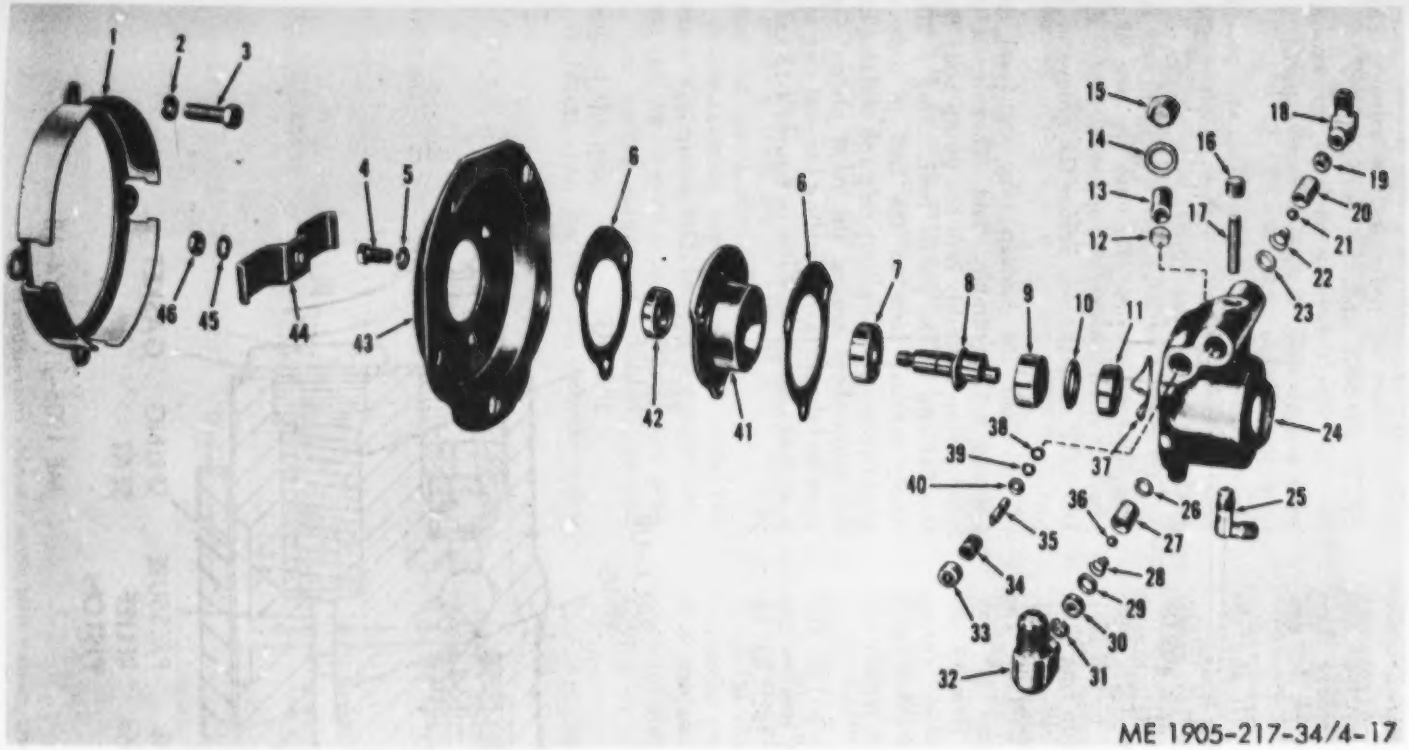
e. Installation. Install the hydraulic starting motor (TM 55-1905-217-12, para 4-63).

4-7. Hydraulic Starter Pump

a. Removal. Remove the hydraulic pump (TM 55-1905-217-12, para 4-63).

b. Disassembly.

(1) Remove the nut (46, fig. 4-17) and lockwasher and withdraw the pump drive (44) from the shaft (8).



1. Drive plate
2. Washer
3. Bolt
4. Bolt, mounting plate to pump
5. Lock washer
6. Gasket
7. Ball bearing
8. Pump shaft
9. Needle bearing
10. Fiber washer
11. Ball bearing
12. Spring seat
13. Pressure relief spring
14. Relief valve plug gasket
15. Relief valve plug
16. Plug
17. Pump piston
18. Pump inlet elbow
19. Check valve retainer
20. Cage
21. Ball
22. Helical spring
23. Baffle
24. Pump body
25. Elbow
26. Baffle
27. Cage
28. Spring
29. Baffle
30. Check valve retainer
31. Spacer
32. Pump outlet elbow
33. Plug
34. Compression spring
35. Pressure relief piston
36. Ball
37. Retaining spring
38. Back-up ring
39. Seal ring
40. Washer
41. Bearing retainer
42. Shaft seal
43. Mounting plate
44. Pump drive
45. Lock washer
46. Nut

Figure 4-17. Starting system hydraulic pump—disassembly and reassembly.

(2) Scribe marks on the mounting plate (43) and the pump body (24) prior to disassembly to ensure their correct reassembly. Remove the three bolts (4) and lock washers and separate the mounting plate (43) from the pump. Remove and discard the gasket (6). Withdraw the bearing retainer (41) from the pump body. Remove and discard the second gasket (6).

(3) Remove the shaft (8), bearings (11), (9), (7) and fiber washer (10) as an assembly from the pump body.

(4) If inspection reveals the bearings and fiber washer are worn excessively remove them from the pump shaft for replacement by new parts.

(5) Remove the pump piston (17) and the retaining spring (37) from the pump body.

(6) Remove the relief valve plug (15), gasket (14), spring (13), and spring seat (12).

(7) Remove the retaining plug (33), compression spring (34), pressure relief piston (35), washer (40), seal ring (39) and backup ring (38).

(8) Remove the pump outlet elbow (32), spacer (31), retainer (30), and baffle (29). The helical spring (28), ball (36) and cage (27) may then be removed as an assembly. Remove the baffle (26). DO NOT separate the helical spring (28) and ball (36) from the cage. If the check valve on either side of the pump is defective, replace the complete check valve assembly.

(9) Remove the pump inlet elbow (18) and the check valve retainer (19). Then remove the cage (20), ball (21), and spring (22) as an assembly. Remove the baffle (23). DO NOT separate the spring (22) and the ball (21) from the cage.

(10) The pump-to-reservoir return elbow (25) and plug (16) may be removed, if necessary, to clean the pump body.

(11) Remove the oil seal (42) from the bearing retainer (41), if the seal is worn or damaged.

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with a solvent (FED. SPEC. PD-680), and dry thoroughly.

(2) Inspect bearing surfaces for excessive wear and scoring. Replace defective parts.

d. Reassembly.

(1) Insert the spring seat (12) and pressure relief spring (13) and lock them in place with a gasket (14) and plug (15).

(2) Slide a new backup ring (38), new seal ring (39) and washer (40) onto the end of the pressure relief piston (35), opposite the flat end. DO NOT slide the seal across the groove in the piston.

(3) Coat the backup ring and seal ring liberally with hydraulic fluid. Then insert the relief piston assembly into the pump body (24), the flat end of the piston first, using J 7192. Apply manual force to the tool in order to gradually work the back-up ring and seal ring into the counterbore around the relief piston. Care must be taken to avoid cutting the seal ring as it is worked into place. Refer to figures 4-18 and 4-19.

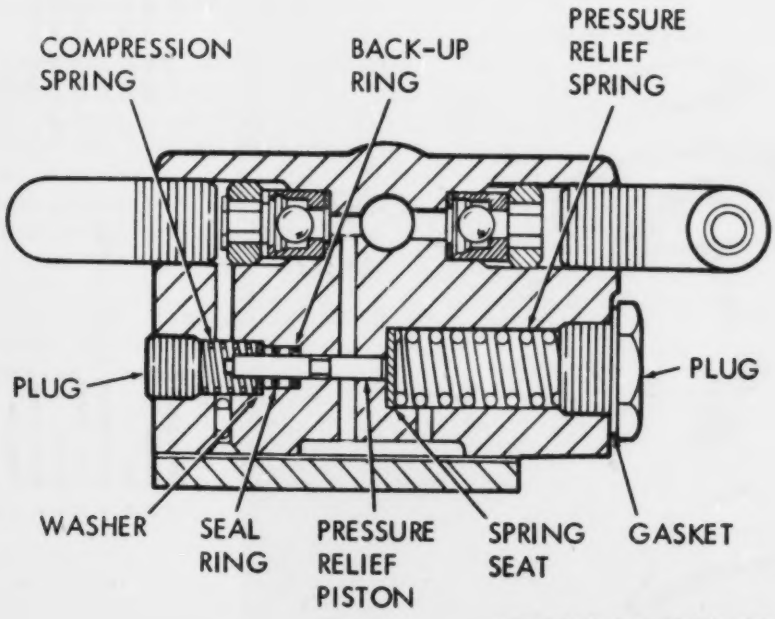


Figure 4-18. Pump pressure relief piston assembly, cross-section view.

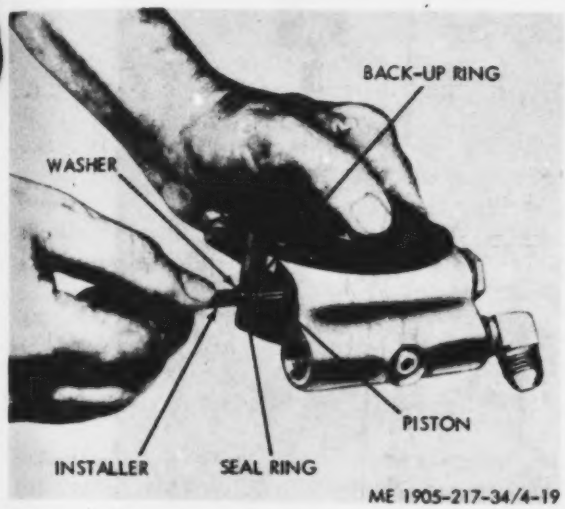


Figure 4-19. Installing pressure relief piston backup ring, seal ring, and washer, with tool J 7192.

(4) Remove the washer (40, fig. 4-17) and inspect the work to make certain the seal ring (39) is completely in the counterbored hole and that the pressure relief piston (35) is down solidly against the spring seat (12).

(5) Reassemble the washer (40) over the pressure relief piston (35), insert the compression spring (34) and secure it in place with the plug (33). Use sealing compound sparingly on the threads of the plug.

(6) Insert the baffle (26), check valve assembly (with the spring end facing out) and the baffle (29) into the pump body. Screw the check valve retainer (30) into the body, against the baffle, and tighten it to 120-140 in-lb torque. Place the spacer (31) in the body on top of the check valve retainer (30) and install pump outlet elbow (32), using sealing compound on the threads. Do not apply sealant on the last thread nearest the open end of the elbow.

(7) Insert the baffle (23) and check valve assembly (with the spring end of the assembly in first) into the pump body. Screw the check valve retainer (19) into the body against the check valve cage (20) and tighten it to 120-140 in-lb torque. Install the pump inlet elbow (18), using sealing compound on all of the threads except the last one nearest the open end of the elbow.

(8) If the pump-to-reservoir return elbow (25) and plug (16) were removed, apply sealant to all except the first threat on the elbow and plug and reinstall them.

(9) Assemble the pump piston (17) and retaining spring (37) in the pump body.

(10) Install the bearing and shaft assembly in the pump body. Work the retaining spring (37) up on the bearing (9).

(11) Affix a new gasket (6) to the pump body (24) and press the bearing retainer (41) by hand into the pump body.

(12) Install a new oil seal (42) in the bearing retainer (41) as follows:

(a) Apply a thin coat of sealing compound to the outer edge of the oil seal casing.

(b) Place the seal lip protector tool J 7191-3 over the shaft, lubricate the lip of the seal and slide the seal, lip side first, over the seal lip protector and down to the bearing retainer, (fig. 4-20).

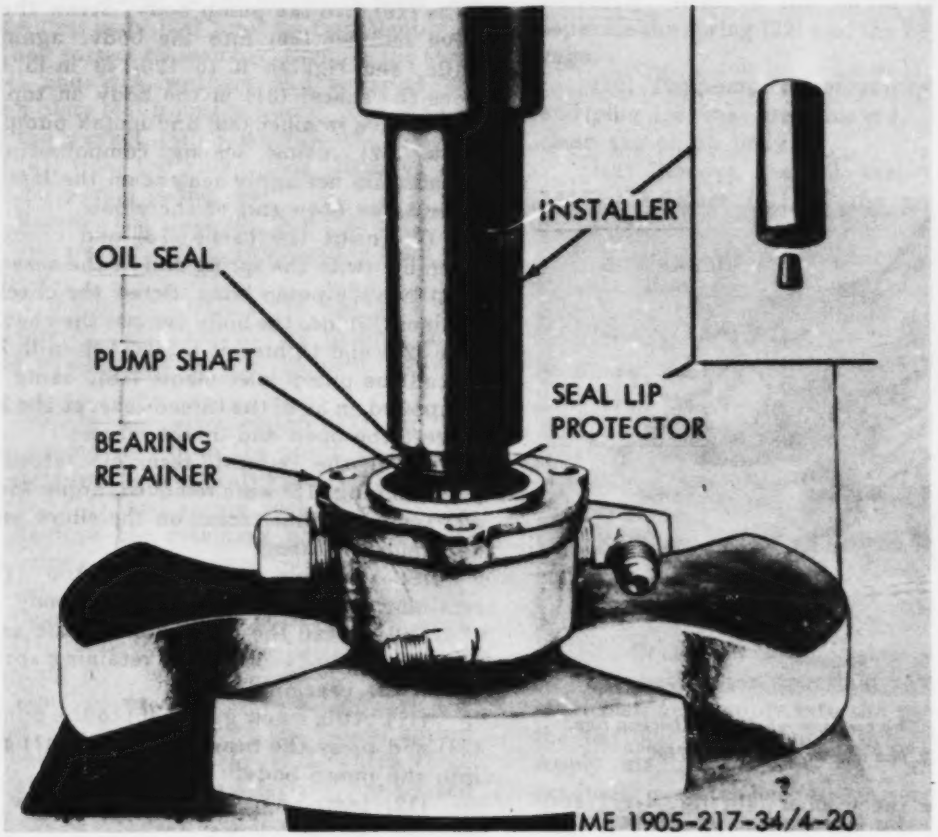


Figure 4-20. Installing shaft seal.

(c) Place the seal installing tool J 7191-1 over tool J 7191-3, covering the threaded end of the shaft. Then, press the seal into the retainer, flush with the retainer surface.

(13) Place a second gasket (6, fig. 4-17) on the bearing retainer. Aline the three bolt holes of the mounting plate (43), bearing retainer (41), pump body (24) and both gaskets (6), and secure the parts together with bolts (4) and lock washers. Make sure the scribe marks previously made on the mounting plate and the pump body are alined to ensure proper position of the pump when it is installed on the engine.

(14) Secure the pump drive (44) on the shaft (8) with a nut (46) and lockwasher.

e. Installation. Install the hydraulic pump (TM 55-1905-217-12, para 4-61).

4-8. Accumulator

a. General. Two accumulators are provided, one mounted on each side of the engine room. When both accumulators are at full pressure, one should be secured (valve closed) and held in reserve. One accumulator will service both engines under normal conditions.

b. Removal.

(1) Close valve on opposite accumulator.

(2) Release oil pressure in the hydraulic starting system lines.

(3) Refer to figure 4-21 and remove accumulator by removing support clamps.

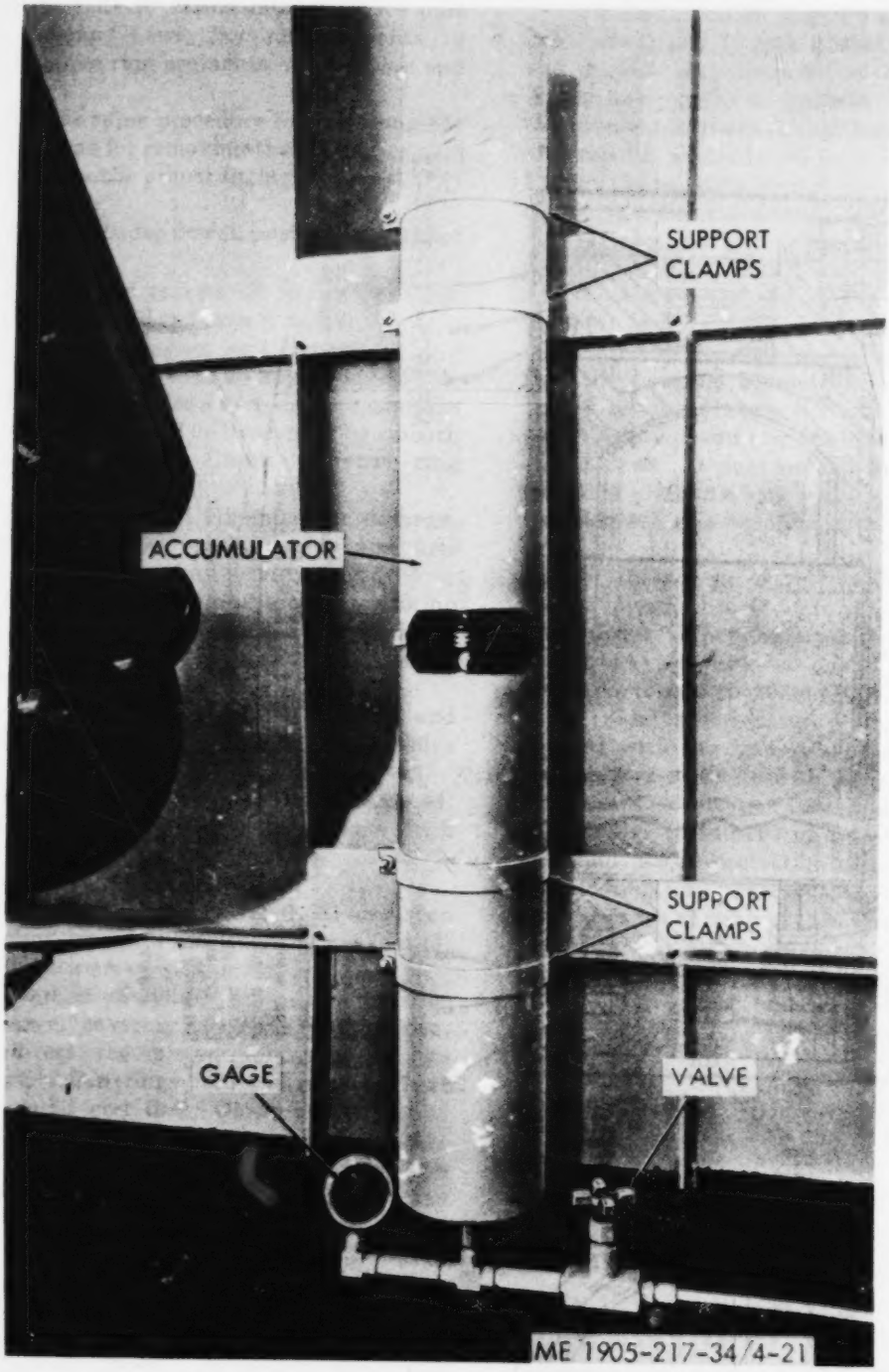
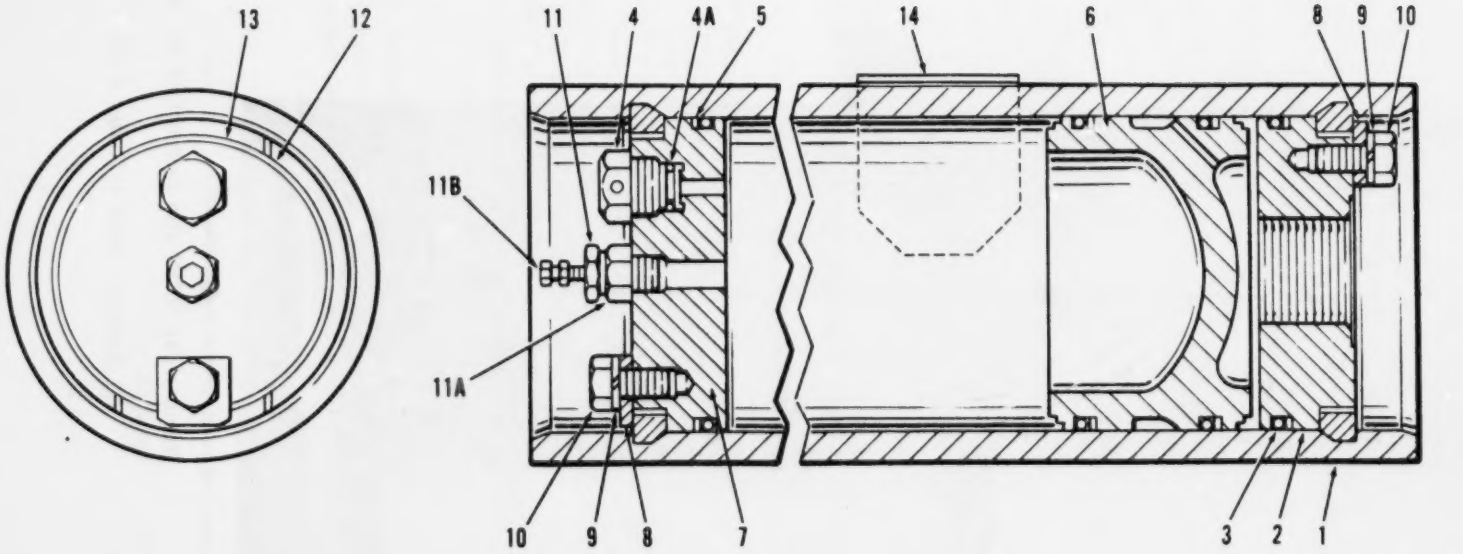


Figure 4-21. Accumulator, gage, and valve, removal and installation.

c. *Disassembly.*

(1) Prior to any disassembly work, the nitrogen gas must be bled from the accumulator. Remove cap (11B) and loosen lock nut until gas escapes.

(2) Remove valve (11, fig. 4-22).



ME 1905-217-34/4-22

1. Housing
2. End cap-oil
3. Gasket
4. Fuse assembly
4A. Fuse assembly gasket
5. Teflon back-up ring
6. Piston
7. End cap-air
8. Retaining plate
9. Lockwasher
10. Screw
11. Air valve assembly-includes 11A and 11B (torque to 45 850 ft. lbs.)
11A. Air valve assembly gasket
11B. Air valve assembly cap
12. Retainer ring segment
13. Retainer ring segment
14. Name plate

Figure 4-22. Accumulator, cross-section view.

(3) Secure housing (1) in a pipe vise and remove screw (10), lockwasher (9), retaining plate (8). Screw ½ inch-20 fitting into air valve port and push end cap (7) away from ring segments (12 and 13). Remove ring segments and pull out end cap (7).

(4) Repeat same procedure for removing the oil end cap (2) as for removing the air end cap (7) being sure to use the proper fitting for the oil port size.

(5) With a wooden dowel, push piston (6) out of cylinder (1).

(6) Remove the gaskets (3) and teflon rings (5) from piston (6) and end caps (2 and 7).

d. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved solvent.

(2) *Housing (1).* Use a drop light to examine the bore of the cylinder. The bore must be smooth and free of scratches. Check segment ring grooves.

(3) *Caps (2 and 7).* Examine for damage. Check fitting threads, valve threads and fuse holder thread if holder has been removed.

(4) *Piston.* Examine for scratches or scoring on o.d. The piston must be checked in cylinder to be sure it moves freely throughout the entire length of cylinder.

(5) *Air valve (11).* Examine threads and replace if damaged. Check for damaged valve seat.

(6) *Teflon rings (5).* Replace if damaged.

(7) *Gaskets (3).* Replace all gaskets with new ones.

e. Reassembly.

(1) Install teflon rings (5, fig. 4-22) on piston (6). Use oil or grease to lubricate the gaskets (3) and install gaskets on piston (6).

(2) Coat i. d. of cylinder with light oil. Use loading sleeve, covering the split ring groove, carefully insert the piston (6) including its gaskets and teflon rings into the housing bore with the closed end first. Observe that teflon rings are correctly installed and gaskets are coated with BM 1546 grease. Gaskets must not be twisted or otherwise damaged. Once piston has entered cylinder, push it half way down in cylinder.

(3) Install teflon rings (5) and gaskets (3) to cap ends (2 and 7) with gasket toward the fluid end. Install teflon rings before installing gaskets. Apply light grease to gaskets (3) to insure that they remain in place. Using loading sleeve, slide end cap (2) with the oil port, into the housing beyond the normal position. Be sure oil end cap is on the side with the head of the piston (6).

(4) Install retainer ring segments (12 and 13) and hold in place. Push piston (6) against oil end cap to position end cap (2) against the retainer plate (8), lock washer and screw (9 and 10).

(5) Using loading sleeve, slide end cap (7) into the housing beyond the normal position. Install retaining rings (12 and 13) and hold in place. Apply pneumatic or mechanical force of 50 lbs. psi max., to position end cap (7) against the retaining plate (8), lock washer and screw (9 and 10). Release pressure and remove assembly fittings.

(6) Install valve (11) with gasket (11A), torque valve (11) to 45-50 ft- lbs DO NOT tighten the locknut. Where safety fuse holder (4) with gasket (4A) was removed, install with new gasket (4A) and torque to 20-25 ft-lbs.

(7) The accumulator is now ready to be charged with nitrogen gas. Continue to charge accumulator until desired pressure is attained. Close valve on nitrogen tank and tighten locknut on air valve to 140-160 in-lbs. Remove charging hose and install protection cap (11B).

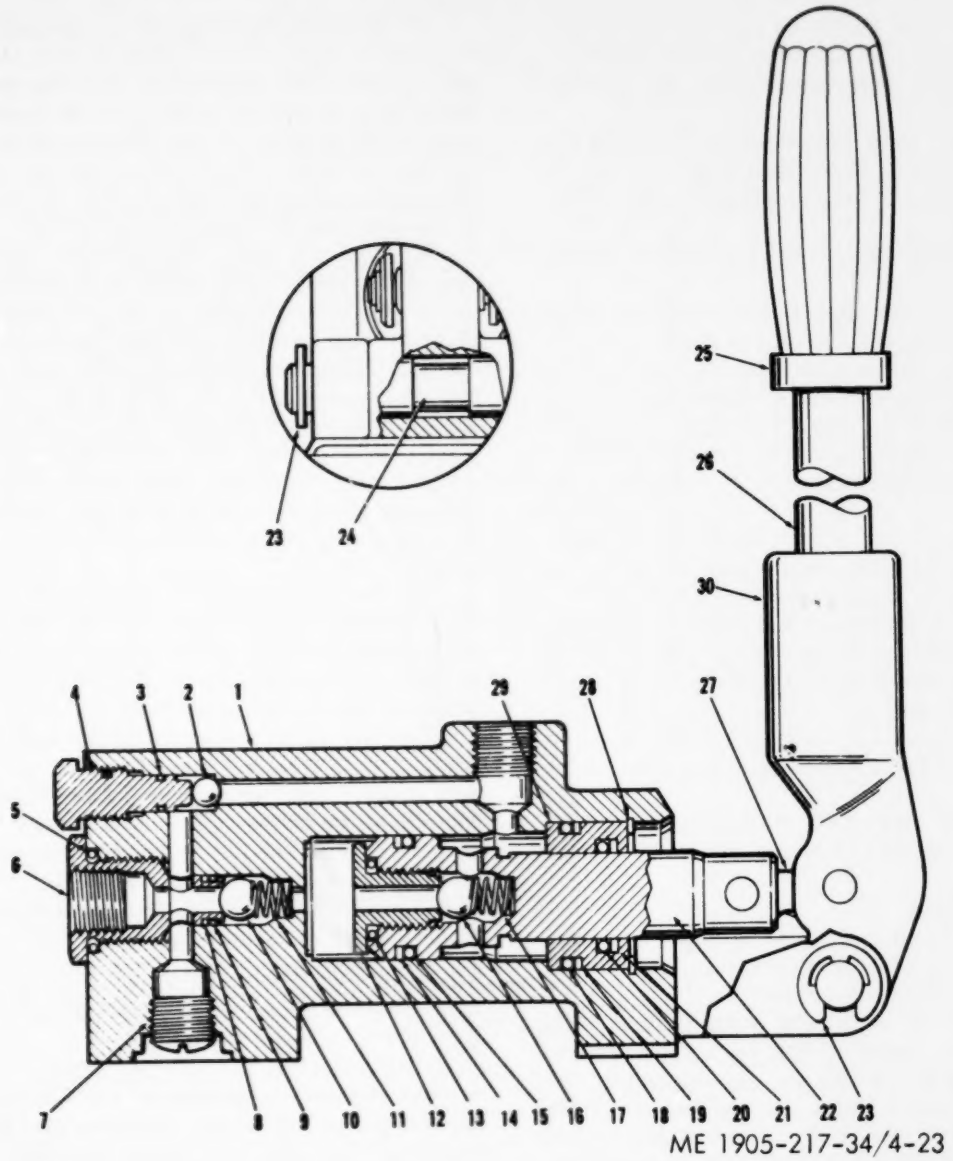
f. Installation. Install the accumulator in reverse order of removal (*b* above).

4-9. Hydraulic Hand pump

a. Removal. Remove the hand pump (TM 55-1905-217-12, para 4-62).

b. Disassembly.

(1) Disconnect operating lever (30, figure 4-23) pump housing (1) and plunger (22). Remove retaining ring (23) and clevis pin (24) before removing link assembly (27).



1. Pump housing
2. Ball valve, bleed
3. Bleed screw gasket
4. Bleeder screw
5. Gasket
6. Oil inlet fitting
7. Plug
8. Inlet fitting backup ring
9. Gasket
10. Inlet check valve
11. Check valve spring
12. Discharge check valve seat
13. Gasket
14. Backup ring
15. Plunger gasket
16. Discharge check valve
17. Check valve spring
18. Plunger gland gasket
19. Backup ring
20. Plunger gland gasket
21. Backup ring
22. Pump plunger
23. Retaining ring
24. Clevis pin
25. Grip
26. Operating lever handle
27. Link assembly
28. Retaining ring
29. Plunger gland
30. Operating lever

Figure 4-23. Hand pump, cross-section view.

(2) Remove plunger gland retaining ring (28) from pump housing (1). Gland (29) will come out on plunger (22) when plunger is pulled from housing (1). Remove gland (29) from plunger.

(3) Remove discharge check valve seat (12) from end of plunger (22). Discharge check valve (16) and spring (17) will drop out of plunger.

(4) Remove oil inlet fitting (6) from end of ump housing. Inlet check valve (10) and spring 11) will drop out of housing (1).

(5) Back out bleeder screw (4) and remove all (2).

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent, (FED. PEC. PD-680) and dry thoroughly.

(2) *Pump housing.*

(a) Check for cracks and other visible amage. Bore of cylinder must be smooth with no itting or scoring. All threads must be checked.

(b) It is not necessary to remove plug (7, igure 4-23) unless there has been leakage at hreads.

(c) Check bleed ball valve (2) and its seat n the housing. Replace ball valve if damaged.

(d) Replace gasket (3).

(3) *Inlet fitting (6).*

(a) Examine internal and external hreads. Inspect inlet check valve seat for nicks or cratches.

(b) Replace gaskets (5 and 9) and backup ng (8).

(c) Inspect inlet check valve ball (10) and pring (11). Replace if damaged.

(4) *Plunger (22).* Check plunger for scoring n large diameter and on plunger shank where it des in gland (29). A wear pattern may be evident ut no scores or scratches should be present. eplace gaskets (13 and 15) and backup ring (14). Examine discharge check valve (16), spring (17), nd check valve seat (12). Replace any damaged arts.

(5) *Plunger gland (29).* With gasket (20) and backup ring (21) removed, check gland on plunger shank to be sure it does not bind. Replace gaskets to be sure it does not bind. Replace gaskets (18 and 20) and backup rings (19 and 21).

d. Reassembly.

(1) Install inlet check valve spring (11, fig. 4-23) and ball (10) into housing (1). With gaskets (5 and 9) and back-up ring (8) on inlet fitting (6), install fitting into housing. Tighten fitting securely being sure that inlet check valve (10) seats properly in end of inlet fitting (6).

(2) Install discharge check valve spring (17) and ball (16) into plunger (22). With gasket (13) in place, thread valve seat (12) into plunger and tighten securely.

(3) Insert plunger (22) into housing bottoming plunger bore. Install plunger gland (29) being sure that external gasket (18) is closest to leading edge. Press gland (29) in until groove for retaining ring is uncovered, then insert ring (28).

(4) Drop bleed ball valve (2) into place and with gasket (3) in position insert bleed screw (4). Tighten bleed screw securely.

(5) Install link assembly (27) to plunger (22) and operating lever (30). Place operating lever (30) in position and insert clevis pin (24) and retaining ring (23). Put other side of link on and secure with clip or cotter pin.

e. Installation. Install the hand pump (TM 55-1905-217-12, para 4-62).

Section III. HYDRAULIC STEERING SYSTEM

-10. General

description of the hydraulic steering system is ncluded in the Operator and Organizational laintenance Manual TM 55-1905-217-12.

-11. Hydraulic Pump Drive

a. General. Steering hydraulic pumps are mounted aft on the outboard engine of each propulsion unit. Pump drive components used on hull number 8500 thru 3519 are shown in figure 4-24. Drive components used on hull number 8520 thru 8560 and 8580 thru 8619 are similar.

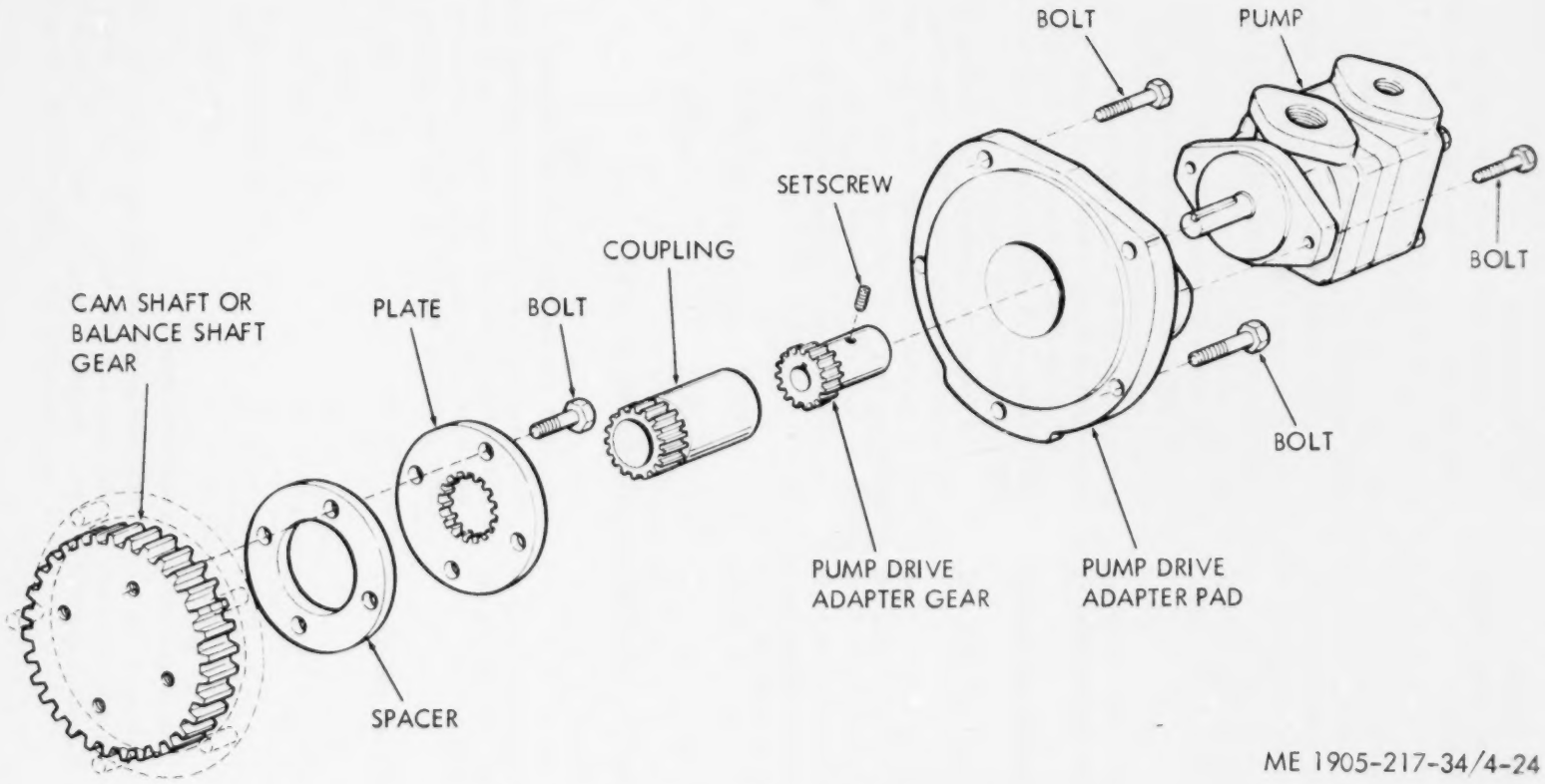


Figure 4-24. Steering pump drive adapter assembly, removal, disassembly, reassembly, and installation.

b. Removal and Disassembly.

(1) Remove the hydraulic pump (TM 55-1905-217-12, para 4-61).

(2) Refer to figure 4-24 and remove the drive adapter assembly components.

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent, FED. SPEC. PD-680) and dry thoroughly.

(2) Inspect parts for cracks, breaks, and other damage. Replace damaged or defective parts.

d. Reassembly and Installation.

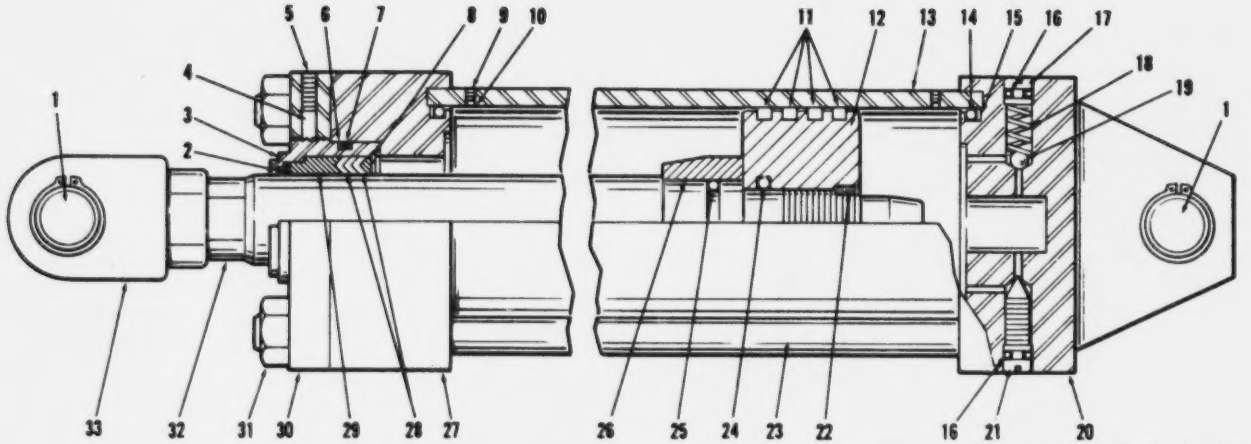
(1) Refer to figure 4-24 and install the pump drive assembly and the pump.

(2) Accurate positioning of the adapter gear on the pump shaft is necessary for proper alignment of the drive components.

4-12. Steering Cylinders

a. Removal. Remove the steering cylinders (TM 55-1905-217-12, para 4-79).

b. Disassembly. Refer to figure 4-25 and disassemble the steering cylinders.



1. Clevis pin
2. Rod wiper
3. Cartridge
4. Cartridge slug
5. Lockscrew
6. Cartridge ring
7. Cartridge packing
8. Packing retaining ring
9. Bleeder screw
10. Bleeder ball
11. Piston packing
12. Piston
13. Tube
14. Preformed packing
15. Ring
16. Preformed packing
17. Ball check screw
18. Ball check spring
19. Ball check ball
20. Cap end cover
21. Adjusting needle
22. Lockscrew
23. Tie rod
24. Preformed packing
25. Preformed packing
26. Head end cushion nose
27. Head end cover
28. V rod packing assembly
29. Rod bearing
30. Cartridge retainer
31. Tie rod nut
32. Piston rod
33. Rod clevis

Figure 4-25. Steering cylinder, cross-section view.

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent (FED. SPEC. PD-680) and dry thoroughly.

(2) Examine the piston rod, (32, fig. 4-25) for scoring. Mild scores or nicks can be removed by light stoning.

(3) Examine all parts for wear or damage.

(4) Replace all seals and packings.

d. Reassembly. Refer to figure 4-25 and reassemble the steering cylinders.

e. Installation. Install the steering cylinders (TM 55-1905-217-12, para 4-79).

4-13. Helm Control Unit

a. Removal. Remove the helm control unit (TM 55-1905-217-12, para 4-82).

b. Disassembly.

(1) If there is a functional problem or leakage at the control section (fig. 4-26) only, the disassembly of the control end of the unit only will be required. For this type of repair, leave the 7-bolted end assembled.

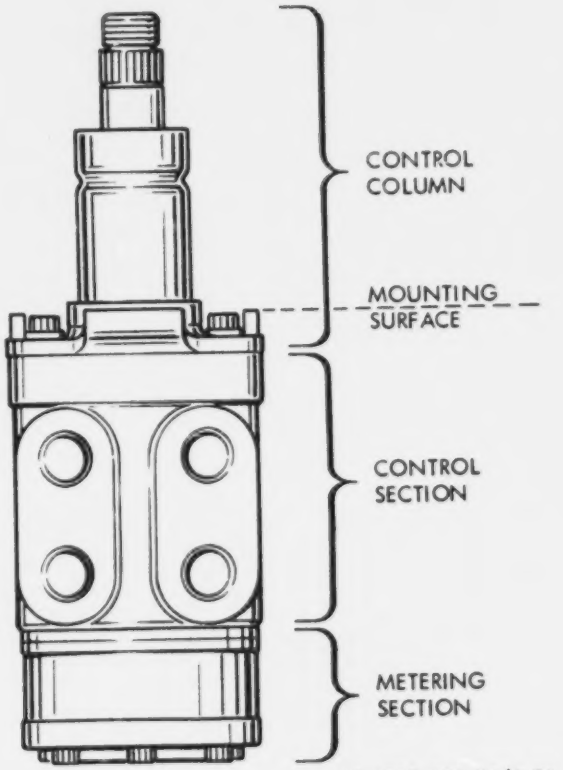
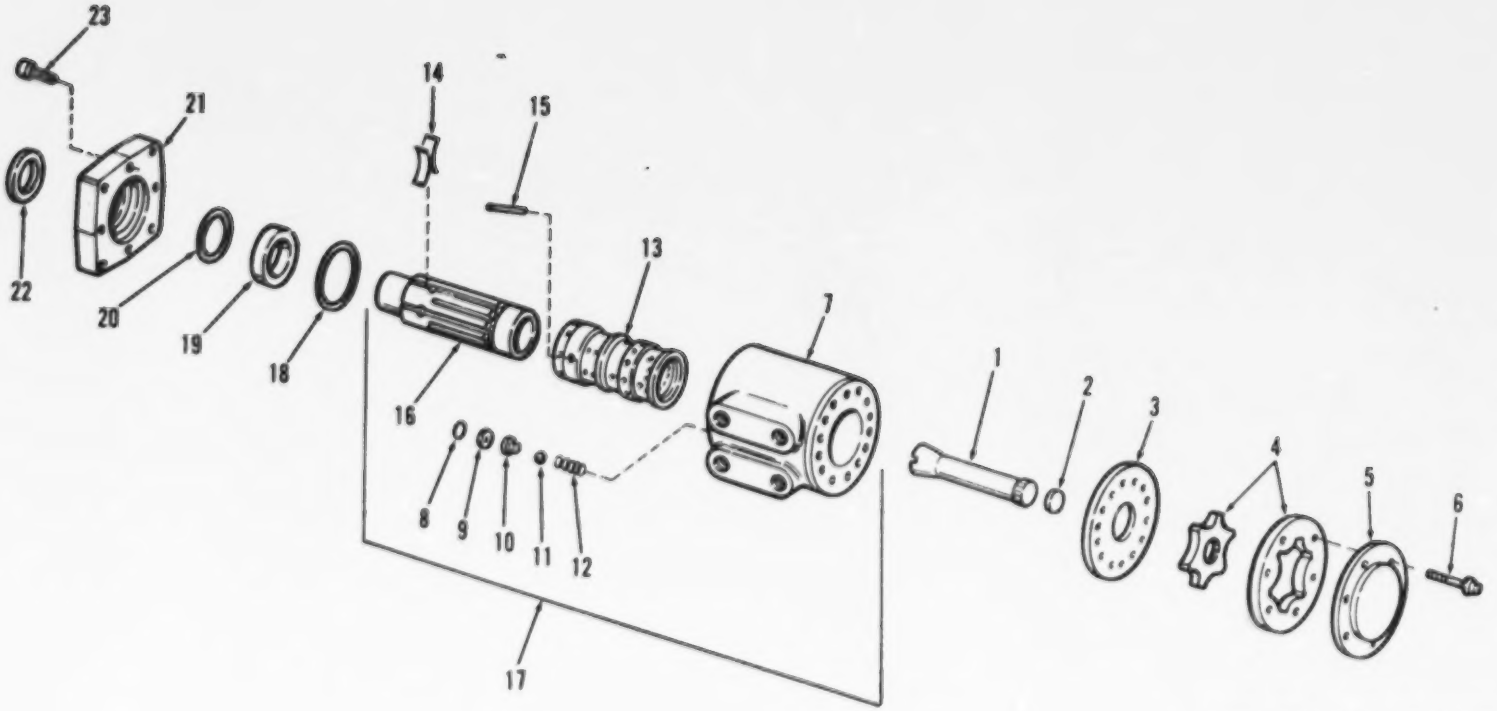


Figure 4-26. Helm unit assembly.

(2) If complete disassembly is planned, clean all paint and surface contamination from the unit at points of separation. To clean the unit, first plug all four ports, then wire brush around the meter area and rinse and blow away all surface contamination.

(3) Place the unit in vise, control end up. Clamp across port surface and opposite side of housing lightly. Remove the two cap screws that fasten column to lower unit. Remove column and set aside. (Mark the two cap screw holes so that the ports will be in the proper direction when reassembled).

(4) Clamp unit in vise across mounting plate (21, fig. 4-27) edges with meter end up. Remove 7 cap screws and carefully lift the metering section from the unit.

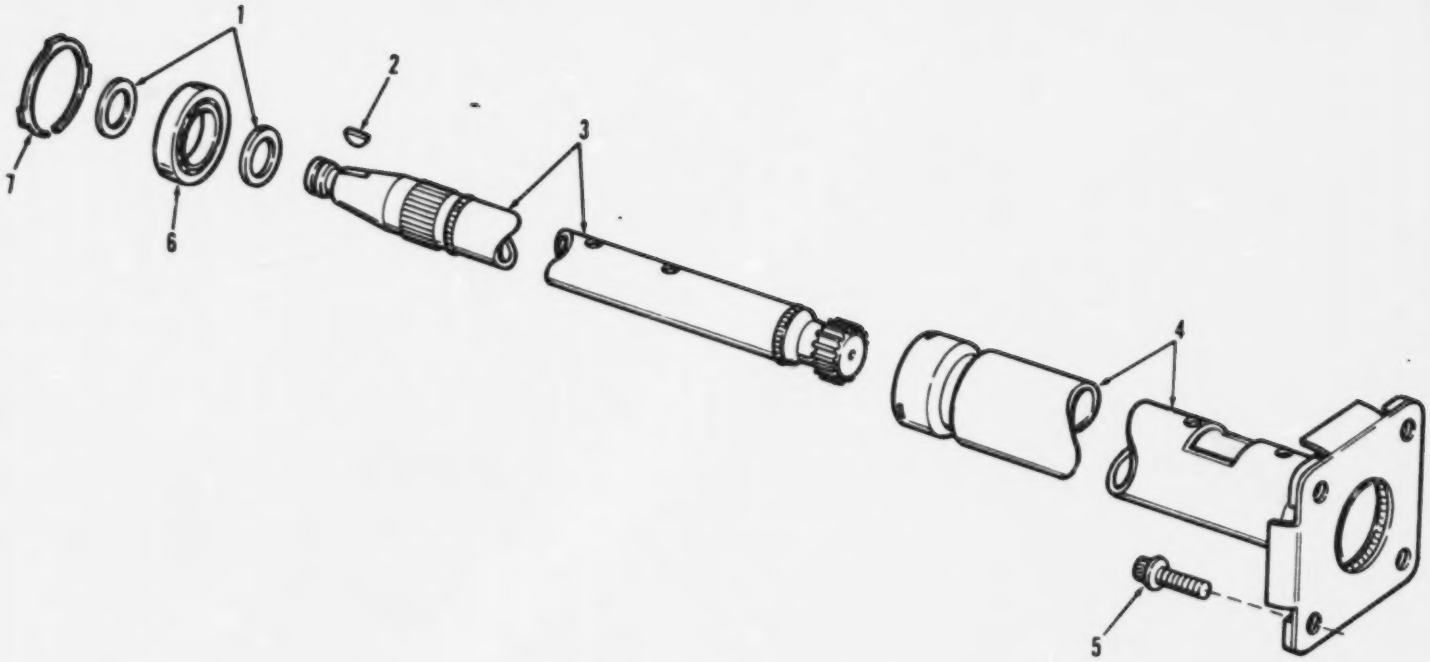


ME 1905-217-34/4-27

1. Drive
2. Spacer
3. Plate
4. Meter gear set
5. End cap
6. Cap screw
7. Valve housing
8. Seal
9. Seal plug
10. Check seat
11. Steel ball
12. Spring
13. Control sleeve
14. Centering spring
15. Centering pin
16. Control spool
17. Control parts assembly
18. Seal
19. Cap locator bushing
20. Quad ring seal
21. Mounting plate
22. Oil screw
23. Cap screw

Figure 4-27. Helm unit control section and metering section, disassembly and reassembly.

(5) Remove control assembly from the vise and use the column shaft (3, figure 4-28) to check for free rotation of the control spool (16, fig. 4-28) to check for free rotation of the control spool (16, fig. 4-27) and sleeve parts.



ME 1905-217-34/4-28

1. Retaining ring
2. Woodruff key
3. Column shaft assembly
4. Tube and flange assembly
5. Cap screw
6. Bearing assembly
7. Retaining ring

Figure 4-28. Helm unit column assembly, disassembly and reassembly.

(6) Place a clean wooden block across the vise throat to support spool parts and clamp unit across port face with control end up. Remove four cap screws (23, fig. 4-27).

(7) Hold spool assembly down against block in vise (fig. 4-29) and lift off end cap. Inspect end cap and housing mating surfaces for obvious leakage path, wear, seal condition.

(8) Remove cap locator bushing (19, figure 4-27).

(9) Place housing on solid surface with port face down, so that it can be held securely, and remove spool-sleeve assembly (16, and 13, fig. 4-27) from the 14 hole end of housing. Be extremely careful to prevent these parts from binding, as they are very closely fitted. They must generally be rotated slightly as they are withdrawn.

(10) Place housing in vise, control end up and unscrew check valve seat (10) with 3/16 hex wrench.

(11) Up end the housing (fig. 4-30) and tap slightly with butt of hand. Hold check valve hole toward lowest corner and remove check valve seat, ball, and spring.

Figure 4-29. Removing end cap.

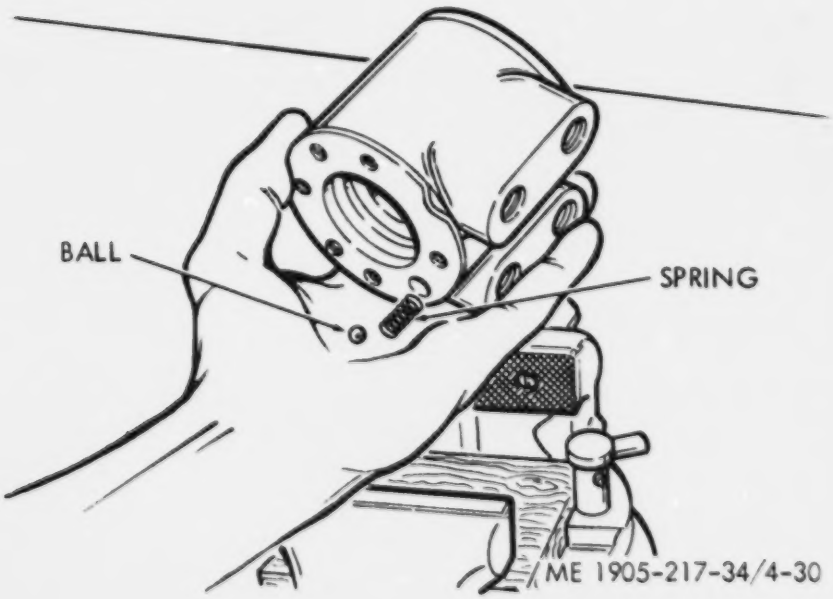


Figure 4-30. Removing check valve seat, ball, and spring.

(12) Remove centering pin (15, fig. 4-27) om spool sleeve assembly. Push inside lower dge of spool (16) so that spool moves toward plined end and remove carefully from sleeve. ush centering spring set (14) out of spring slot in pool.

c. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent, (FED. PEC. PD-680). Set parts on a clean paper towel o dry.

(2) Disassemble meter gear set (4, fig. 4-27) nd clean with solvent.

(3) Inspect all moving surfaces to insure that hey have not been scored or abraded by dirt articles or otherwise disrupted. Smooth burished surfaces are normal in many areas. lightly scored parts can be cleaned with 600 grit brasive paper by hand rubbing only.

(4) To prepare all surfaces of the meter ection for reassembly and insure that all edges of he parts are burr free, place a piece of 600 grit brasive paper face up on an extremely flat, clean, ard surface. The surface to be used for this urpose should be as flat as plate glass or better. f the 600 grit paper is new it should first be ubbed down with a scrap steel part to remove harp grit which would produce scratches. The nds of the star gear (4, fig. 4-27) can be used for his purpose if necessary. Then both sides of the ing gear (4), both sides of the plate (3), the 14 ole end of the housing (7) and the flat side of the nd cap (5) should be cleaned lightly. Stroke each urface across the abrasive several times and bserve the part. Any small bright area near an dge indicates a burr which must be removed. Hold the part so that contact with the abrasive is s flat as possible. (Do not push one edge down ard or the flatness will become rounded). Check ach part after 6 to 10 strokes across the abrasive. After polishing each part, rinse clean in solvent nd blow dry. Keep these parts absolutely clean ntil they are assembled.

d. Reassembly.

(1) Place clean wooden block across vise hroat and place housing in vise with control end p. Clamp across port surface lightly.

(2) Drop check valve spring (12, fig. 4-27) nto the check hole with large end down. Drop heck ball (11) into check hole and insure that it ests on top of the small end of the spring within he hole. Place the check valve seat (10) on hex rench and screw into threads within check hole o that machined counterbore of the check seat is oward the ball. Tighten check seat to 150 inchounds torque. Test check ball action by pushing all with small clean pin against spring force. Ball eed not be snug against seat for proper function.

(3) Install spool (16) within sleeve (13) carefully so that spring slots of both parts will be at same end. Rotate while sliding parts together. Test for free rotation. Spool should rotate smoothly in sleeve with finger tip force applied at splined end. Bring spring slots of both parts in line and stand parts on end of bench. Insert spring installation tool through spring slots of both parts. Tool is available as Part No. 60057. Position 3 pairs of centering springs (or 2 sets of 3 each) on bench so that extended edge is down and arched center section is together. In this position, center one end of spring set into spring installation tool. Compress extended end of centering spring set and push into spool sleeve assembly withdrawing installation tool at the same time. Center the spring set in the parts so that they push down evenly and flush with the upper surface of the spool and sleeve. Install centering pin (15) through spool assembly. Push into place until centering pin is flush or slightly below the sleeve diameter at both ends.

(4) Position the housing on a solid surface with the port face down. Start the spool assembly so that the splined end of the spool enters the 14 hole end of the housing first. Be extremely careful that the parts do not cock out of position while entering. Push parts gently into place with slight rotating motion. Bring the spool assembly entirely within the housing bore until the parts are flush at the meter end or 14 hole end of the housing. Do not pull the spool assembly beyond this point (to prevent the cross pin from dropping into the discharge groove of the housing). With the spool assembly in this flush position, check for free rotation within the housing by turning with light finger force at the splined end. Hold the parts in this flush position and rest the 14 hold end of the assembly on the protective block on the vise throat and clamp lightly across the port face with the vise.

(5) Install a new seal (8) on the plug (9). Install the plug in the check hole with a steady pressure while rocking is slightly so the seal (8) feed in smoothly without cutting.

(6) Position the cap locator bushing (19) with large O.D. chamfer UP partly into end of housing. Insure that it seats against spool assembly flat and smooth by rotating with finger tips.

(7) Check the mounting plate (21) and shaft seal (20) carefully to insure that they are clean and in good condition. Insure that the mounting plate seal grooves are clean and smooth. Each of these seals is slightly larger than its seal groove so that they will be adequately retained in service. Push each gently into place and smooth down into seal groove with finger tip. Thin oil seal (22) at exterior of mounting plate is a dirt exclusion seal

and does not generally need replacement. If this is replaced it should be pressed into counter-bore so that the lip is directed away from the unit. Place the mounting plate subassembly over spool shaft and slide down into place over cap locator bushing smoothly so that seals will not be disrupted in assembly. Aline bolt holes with tapped holes. Be certain that the mounting plate rests fairly flush against end of housing assembly so that the cap locator bushing is not cocked. Install four mounting plate cap screws. Tighten these evenly and gradually to a torque setting of 250 inch pounds.

(8) Reposition housing in vise (14 hole surface up) and clamp across the edges of the mounting plate. Check to insure that spool and sleeve are flush or slightly below the 14 hole surface of the housing. Clean the upper surface of the housing by wiping with the back of a clean hand or the butt of the thumb. Clean each of the flat surfaces of the meter section parts as it is ready for assembly in a similar way.

(9) Place the plate (3) over the housing assembly so the bolt holes in the plate align with the tapped holes in the housing. Place the meter gear ring (4) on the assembly so the bolt holes aline. Place the splined end of the drive within the meter gear star so that the slot at the control end of the drive is in alignment with the valleys between the meter gear teeth (fig. 4-31). Push the splined end of the drive through the gear so that the spline extends about one half its length beyond the meter gear star and hold it in this position while installing into the unit. Note the position or direction of the centering pin within the unit. Enter the meter gear star into the meter gear ring and wiggle the parts slowly in position so that the drive does not become disengaged from the meter gear star. Hold the plate and meter gear ring in position on the assembly while the star is being installed. Rotate the meter gear star slightly to bring the cross slot of the drive into engagement with the centering pin and the splined end of the drive will drop down against the plate.

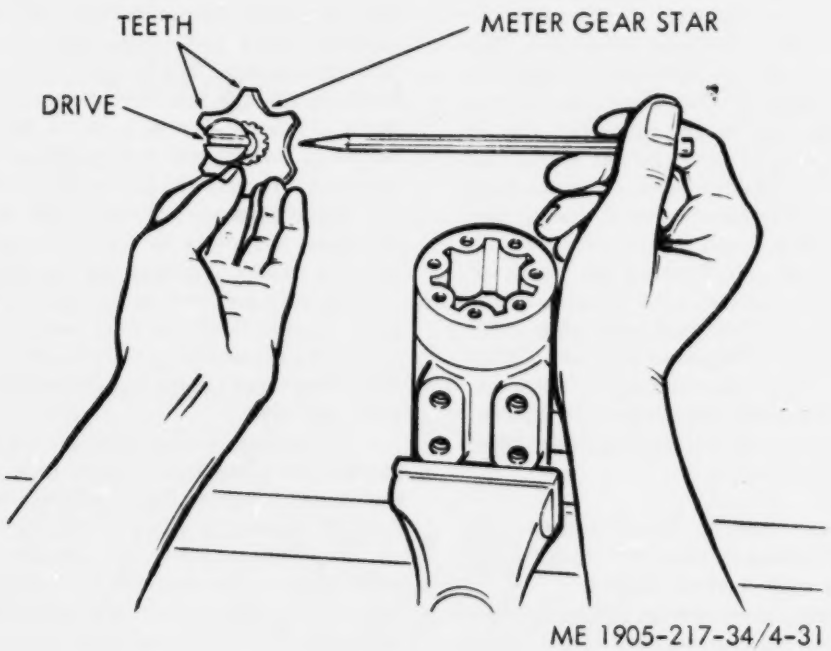


Figure 4-31. Drive and meter gear star.

CAUTION

Alinement of the cross slot in the drive with valleys between the teeth of the meter gear star determines proper valve timing of the unit. There are 12 teeth on the spline and 6 pump teeth on the star. Alinement is exactly right in 6 positions and exactly wrong in 6 positions. If the parts slip out of position during this part of the assembly, repeat until you are certain that correct alinement is obtained.

(10) Place the spacer (2) in position within the end of the meter gear star. If the spacer does not drop flush with the gear surface, the drive has not properly engaged the centering pin-RECHECK. Place the meter end cap over the

assembly and install two cap screws, finger tight, to maintain alignment of the parts. Install all seven cap screws and bring them gradually and evenly to 150 inch pounds torque.

(11) Check the condition of the column assembly, clean it, and replace on the unit with two cap screws oriented as before. Rotate the steering shaft while bringing the surfaces into contact to allow splines to engage. Tighten cap screws to 280 inch pounds.

e. Installation. Install the helm control unit (TM 55-1905-217-12, para 4-82).

4-14. Steering System Valves

a. General.

(1) Refer to Operator and Organizational Maintenance Manual TM 55-1905-217-12 for diagram of steering hydraulic system.

(2) Malfunctioning of relief valves, flow control valves, overcenter valves, and counterbalance valves can normally be remedied by cleaning, adjustment, or replacing seals. If inspection shows worn seats or other physical damage, replace the valve.

b. Steering System Valves Removal - Hulls 8500-8519.

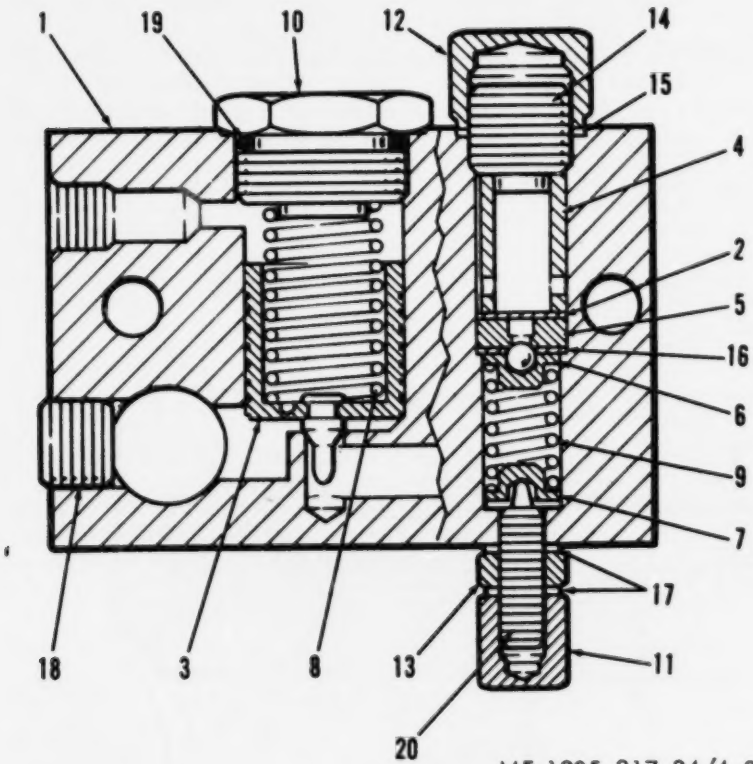
(1) *Overcenter valve removal.*

(a) This valve is located in the center of the engine room, near the aft bulkhead, just below the deck. It is connected into both lines between helm unit and steering cylinder valves (four connections).

(b) Drain steering hydraulic system to a level below the valve. Refer to TM 55-1905-217-12, figures 1-9 and 1-10.

(c) Disconnect tube connections and remove valve.

(2) *Relief valve removal (fig. 4-32).*



ME 1905-217-34/4-32

1. Body
2. Orifice plate
3. Valve piston
4. Spacer
5. Seat
6. Spring end assembly
7. Spring end
8. Spring
9. Spring
10. Plug
11. Cap
12. Cap
13. Nut
14. Screw
15. Gasket
16. Gasket
17. Gasket
18. Plug
19. Preformed packing
20. Screw

Figure 4-32. Steering system relief valve, cross-section view.

(a) The relief valve is located in the engine room, near the aft bulkhead, just below the deck, and near the pump discharge valves. It is connected into the pressure line between the check valves and the 10 gallon tank.

(b) Drain steering hydraulic system to a level below the valve. Refer to TM-55-1905 217-12, figures 1-9 and 1-10.

(c) Disconnect the tube connections and remove the valve.

(3) *Flow control valve removal.*

(a) This valve is in the engine room, near the aft bulkhead, just below the deck, and near the relief valve. It has three tube connections, one in the pressure line, one to the helm unit, and the other connection is to the return line to the tank.

(b) Drain steering hydraulic system to a level below the valve. Refer to TM 55-1905-217-12, figures 1-9 and 1-10.

(c) Disconnect the tube connections and remove the valve.

c. Steering System Valves Removal - Hulls 8520-8560 and 8580-8618.

(1) *Relief valve removal.*

(a) This relief valve is located in the helm unit well, just above the engine room, with access from the engine room or through pilot house access plate. It is connected between the pressure line and the return line from helm unit to tank.

(b) Drain steering hydraulic system to a level below the valve. Refer to TM 55-1905-217-12, figures 1-9 and 1-10.

(c) Disconnect pipe connections and remove valve.

(2) *Flow divider removal.*

(a) The flow divider is located in the center of the engine room just below the deck. It has pipe connections in the pressure line to the helm unit and also has hose connecting lines to tank lines.

(b) Drain steering hydraulic system to a level below the valve. Refer to TM 55-1905-217-12, figures 1-9 and 1-10.

(c) Disconnect hose connections and pipe connections and remove the flow divider.

(3) *Counterbalance valve removal.*

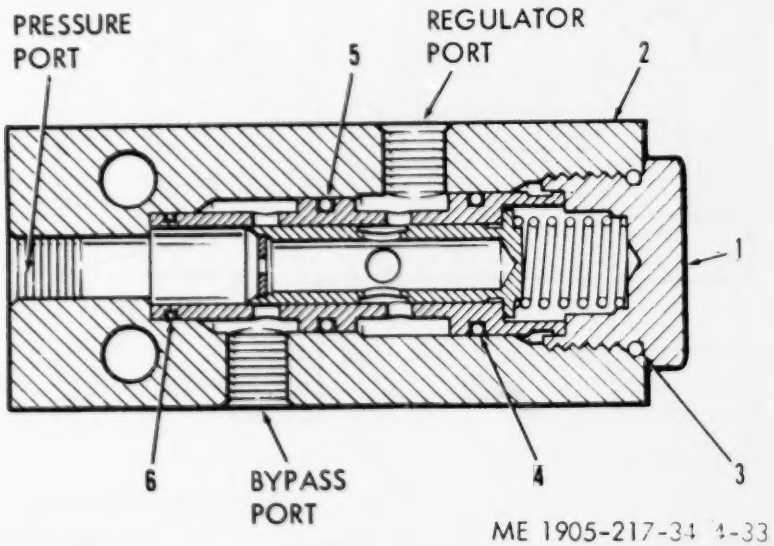
(a) The counterbalance valves (2) are in the center of the lazarette just below the deck.

(b) Drain the steering hydraulic system to a level below the valves.

(c) Disconnect hoses and pipes and remove valves.

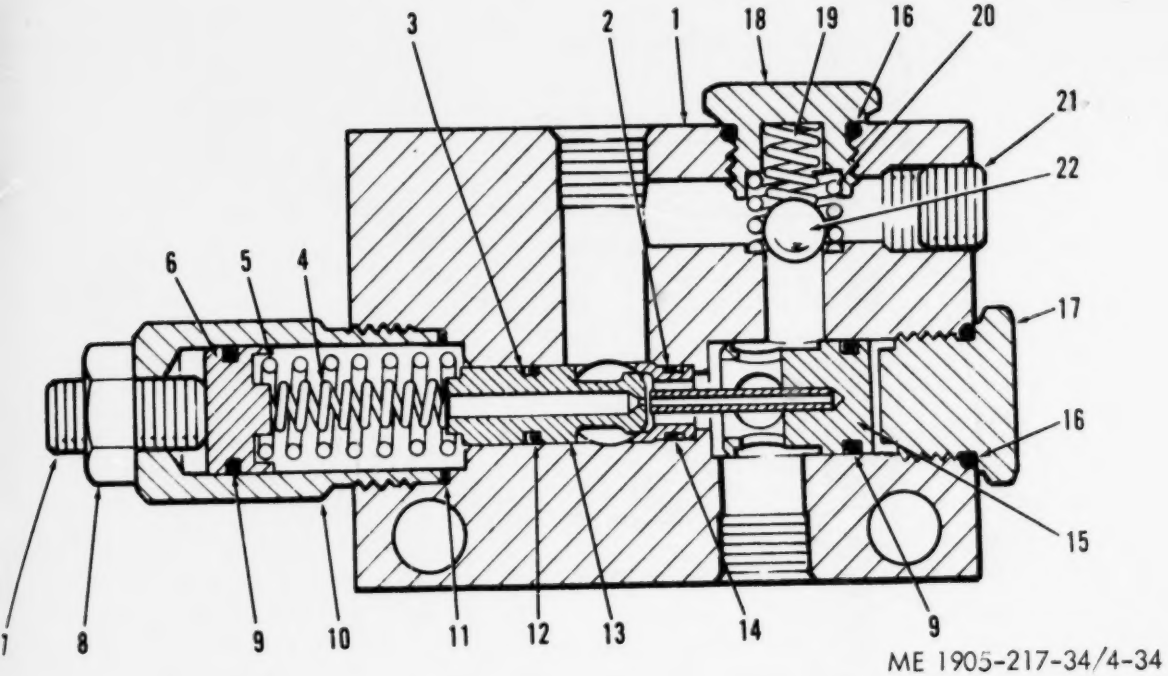
d. Steering System Valves, Disassembly and Repair - Hulls 8500-8519.

Refer to figures 4-32, 4-33, 4-34, and replace packing gaskets and/or mounting hardware as necessary.



1. Cartridge
2. Body
3. Preformed packing
4. Preformed packing
5. Preformed packing
6. Preformed packing

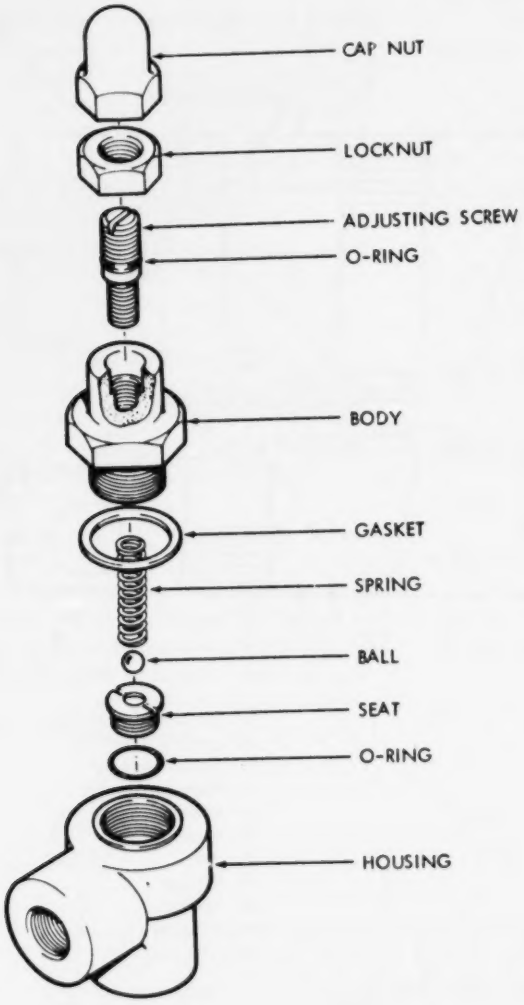
Figure 4-33. Steering system flow control valve, cross-section view.



1. Body
2. Preformed packing
3. Leather back-up
4. Spring
5. Spring
6. Spring end
7. Screw
8. Nut
9. Preformed packing
10. Plug
11. Gasket
12. Preformed packing
13. Lapped assembly
14. Teflon back-up
15. Piston assembly
16. Preformed packing
17. Plug
18. Plug
19. Spring
20. Spring
21. Pipe plug
22. Ball

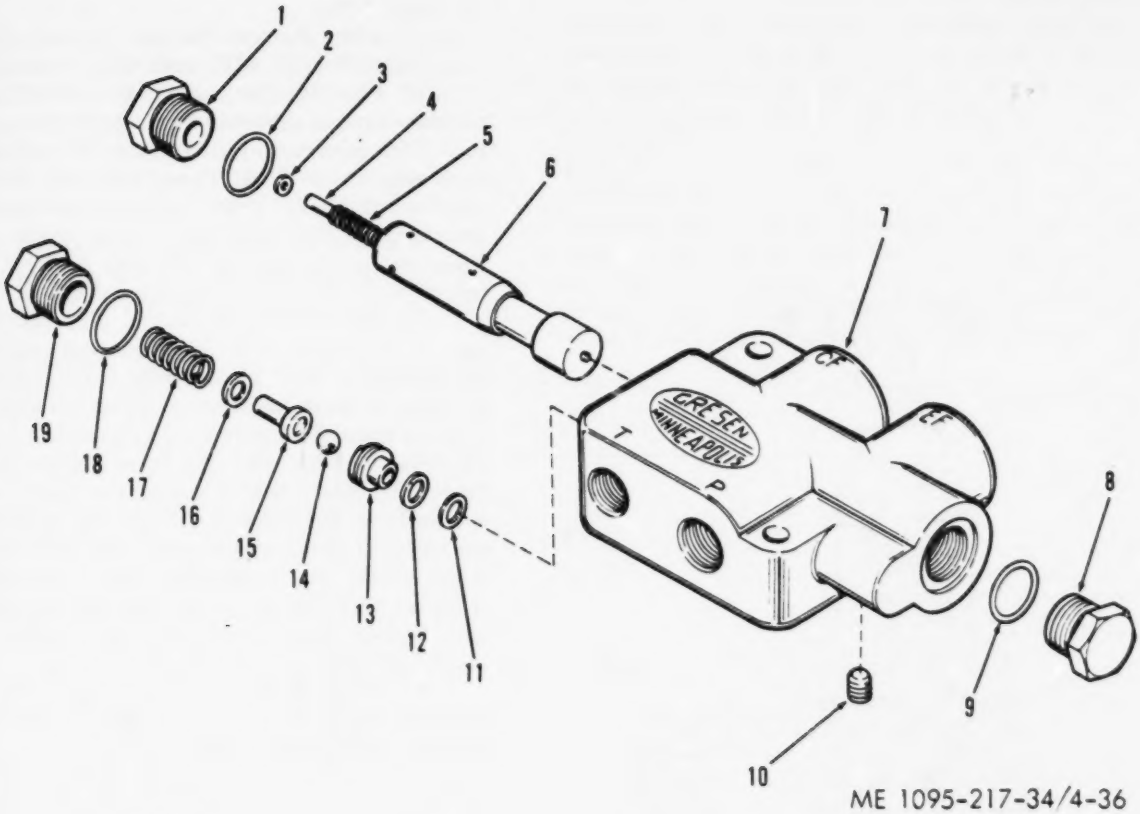
Figure 4-34. Steering system double over center valve, cross-section view.

e. Steering Unit Valves, Disassembly and epair—Hulls 8520-8560 and 8580-8619. Refer to figures 4-35, 4-36, and 4-37 for disassembly and repair of the valves on these vessels.



ME 1905-217-34/4-35

Figure 4-35. Steering system relief valve (hulls 8520-8560 and 8580-8618).



1. Cap
2. Preformed packing
3. Shim
4. Guide
5. Spring
6. Spool
7. Housing
8. Cap
9. Preformed packing
10. Plug
11. Preformed packing
12. Washer
13. Relief seat
14. Ball
15. Guide
16. Relief shim
17. Relief spring
18. Preformed packing
19. Relief cap

Figure 4-36. Steering system flow divider (hulls 8520-8560 and 8580-8618).

f. Steering System Valves, Installation.

(1) Install valves in reverse order of removal.

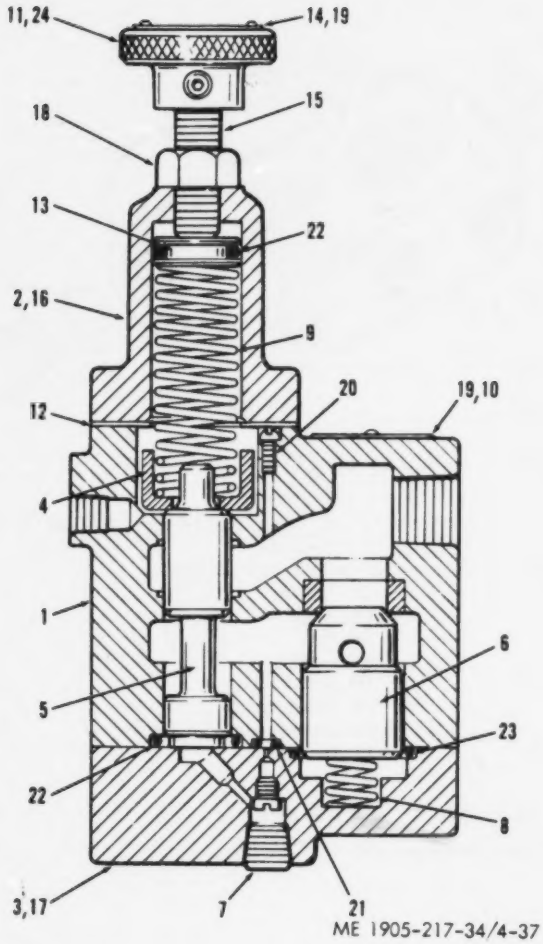
(2) Refill tanks and lines, (TM 55-1905-217-12, para 4-76).

g. Steering System Valves, Adjustment-Hull Nos. 8520 through 8560 and 8580 through 8618.

(1) *Flow Divider valve (fig. 4-36).* The flow divider valve is adjusted to a 2 gpm flow at 1050 psi. The pressure is adjusted by adding or removing shims (16). Three sizes of shims are used—.042 inch thick effects pressure approximately 300 psi; .021 inch thick effects pressure approximately 105 psi; and .010 inch thick which effects pressure approximately 75 psi.

(2) *Relief Valve (fig. 4-35).* The relief valve can be adjusted at first or second echelon of maintenance. For Hulls 8500-8519, adjust by putting the helm hardover in either direction with engines running (1 pump only supplying system). Remove cap from the relief valve, loosen nut, and back off screw until it no longer bears on the spring. Hold the helm in a hardover position and slowly turn down screw until the pressure gage reads 1,500 psi indicating that the valve is relieving at 1,500 psi. Lock this setting with nut and replace cap. For Hulls 8520-8539, valve maximum pressure setting is 1050 psi.

(3) Counterbalance Valve (fig. 4-37). The counterbalance valve is adjusted to 1,000 psi by turning the control knob.



1. Body
2. Cap-top
3. Cap-bottom
4. Spring seat and stop
5. Spool (main)
6. Spool (check)
7. Pipe plug
8. Spring (check)
9. Spring (main)
10. Name plate
11. Hand knob
12. Gasket
13. Spring follower
14. Name plate
15. Screw
16. Screw
17. Screw
18. Full nut
19. Drive screw
20. Screw
21. Preformed packing
22. Preformed packing
23. Preformed packing
24. Setscrew

Figure 4-37. Steering system counter balance valve (hulls 8520-8560 and 8580-8618).

Section IV. RAMP HOIST HYDRAULIC SYSTEM

4-15. General

Refer to the Operator and Organizational Maintenance Manual TM 55-1905-217-12 for descriptions of the ramp hoist systems. Following paragraphs cover components used in two different systems-one group of components for hull no. 8500 thru 8519 and the other components for hull number 8520 thru 8560 and 8580 thru 8619.

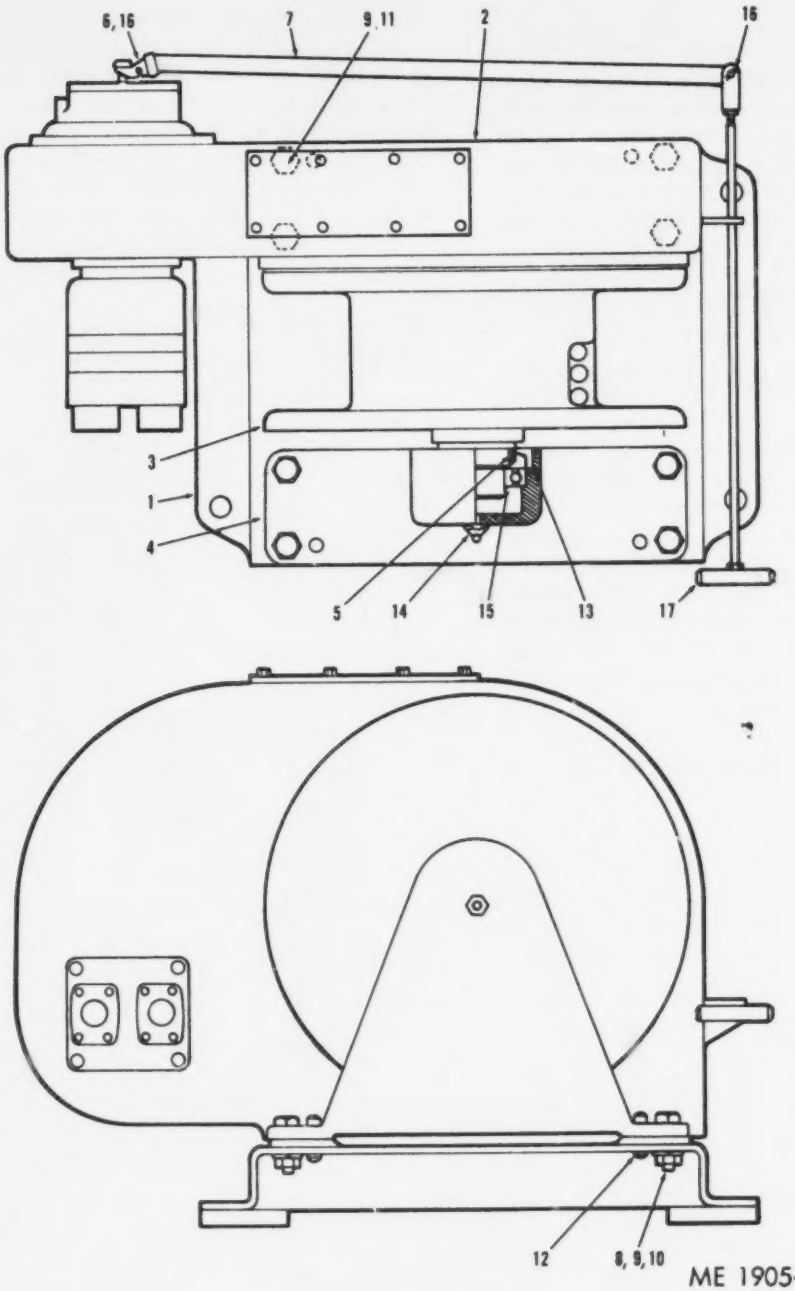
4-16. Winch-Hull Number 8500 thru 8519

a. General. Refer to Operational Maintenance Manual TM 55-1905-217-12 for description of this winch.

b. Removal. Remove the winch (para 2-9).

c. Disassembly. When removing components from the system, disconnect hydraulic lines, cap open ends, and leave lines in place unless in need of replacement. Fittings may be left in components unless fittings are damaged or components are to be replaced. Disassemble winch, gear reducer, and brake only to the extent necessary to inspect for and repair or replace defective parts. When breaking hydraulic line connections, cap all open line ends and ports.

(1) *Winch.* Refer to figure 4-38. Remove drum support (4) from base (1) and drum (3) and slide drum from reduction gear output shaft.

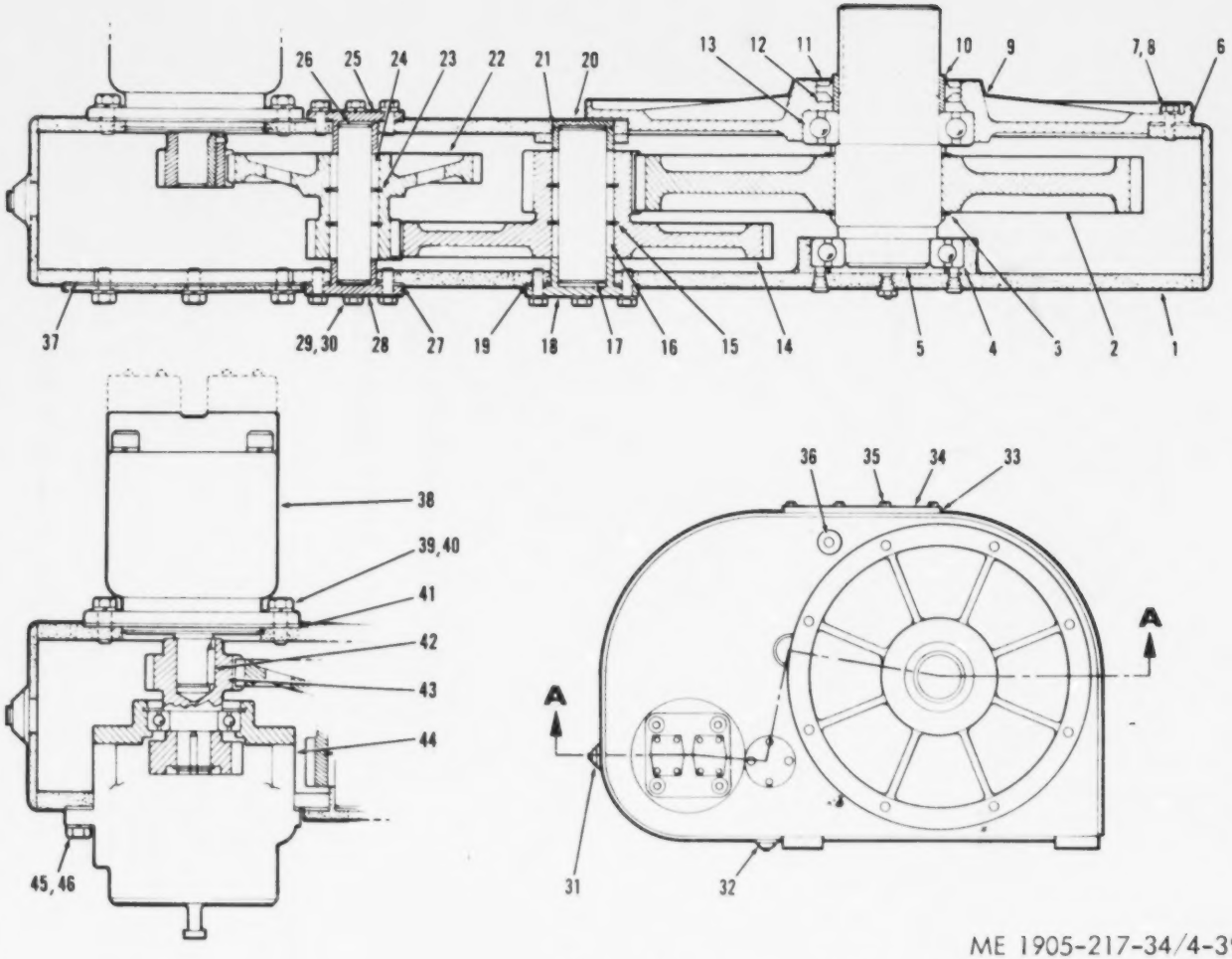


ME 1905-217-34/4-38

1. Base
2. Gear reducer
3. Drum assembly
4. Support
5. Bushing
6. Pivot pin
7. Handle
8. Nut
9. Lockwasher
10. Capscrew
11. Capscrew
12. Dowel pin
13. Oil seal
14. Grease fitting
15. Ball bearing
16. Cotter pin
17. Handle grip

Figure 4-38. Winch assembly, (hulls 8500-8519).

(2) *Gear reducer.* Refer to figure 4-39. Drain lubricant and remove gearbox cover plate (34). Internal parts will then be visible for inspection. If further disassembly is required, remove winch drum and remove flange (9), motor (38), and brake (44) to allow removal of cluster gears and shafts.



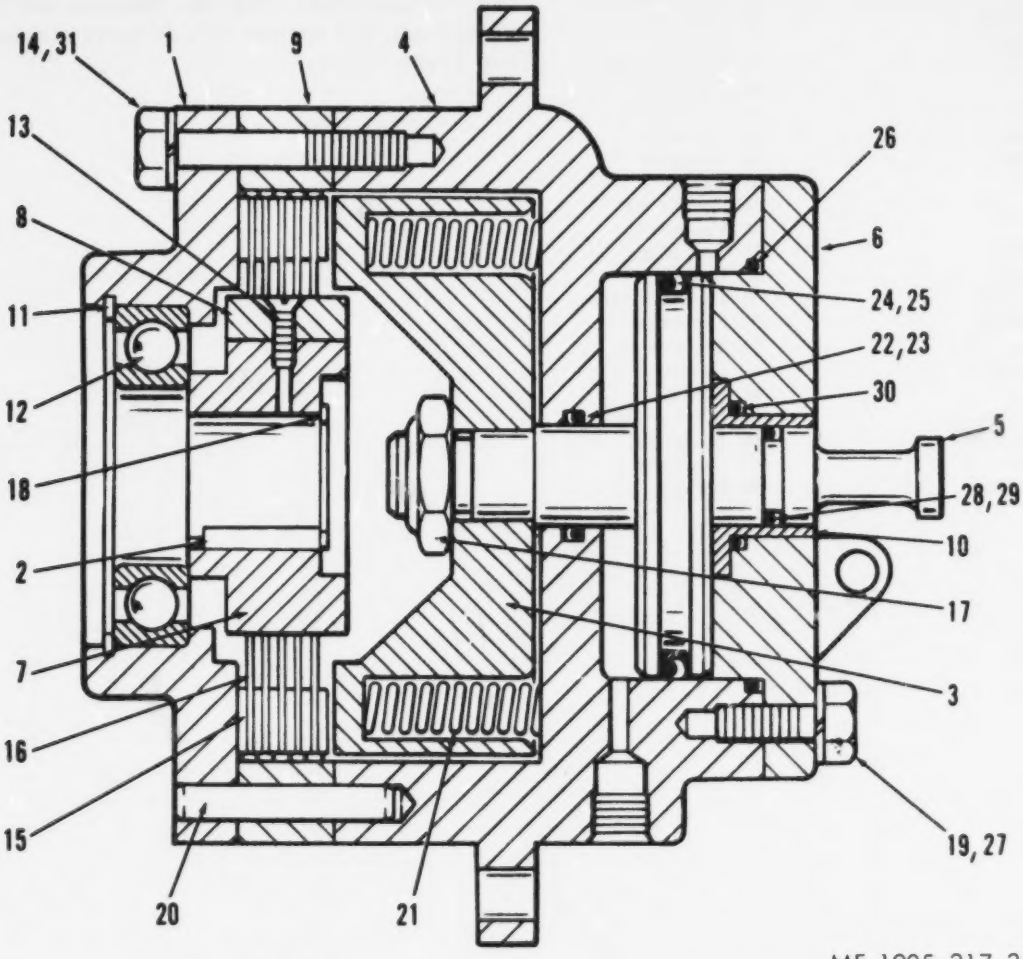
ME 1905-217-34/4-39

Figure 4-39. Winch gear reducer (hulls 8500-8519).

Key to figure 4-39.

1. Housing
2. Spur gear
3. Retaining ring
4. Ball bearing
5. Drum shaft
6. Gasket
7. Capscrew
8. Lockwasher
9. Case flange
10. Spacer
11. Oil seal
12. Oil seal
13. Ball bearing
14. Cluster gear
15. Retaining ring
16. Roller bearing
17. Idler shaft
18. Shaft retainer
19. Gasket
20. Shaft cap
21. Preformed packing
22. Cluster gear
23. Retaining ring
24. Roller bearing
25. Shaft retainer
26. Idler shaft
27. Gasket
28. Shaft retainer
29. Cap screw
30. Lockwasher
31. Pipe plug
32. Pipe plug
33. Gasket
34. Cover plate
35. Cap screw
36. Pipe plug
37. Gasket
38. Hydraulic motor
39. Cap screw
40. Lockwasher
41. Gasket
42. Key
43. Drive pinion
44. Brake
45. Cap screw
46. Lockwasher

(3) *Brake.* Refer to figure 4-40. Remove cap (1), bearing (12), and hub (7). Remove plates (15 and 16) and brake ring (9). Remove nut (17), plunger (3), and springs (21). Remove end cap (6) and brake rod (5).



1. Bearing cap
2. Key
3. Brake plunger
4. Housing
5. Brake rod
6. End cap
7. Hub
8. Key
9. Ring
10. Bushing
11. Retaining ring
12. Ball bearing
13. Machine screw
14. Cap screw
15. Driving plate
16. Driven plate
17. Stop nut
18. Retaining ring
19. Lockwasher
20. Dowel pin
21. Spring
22. Preformed packing
23. Back-up ring
24. Preformed packing
25. Back-up ring
26. Preformed packing
27. Cap screw
28. Preformed packing
29. Back-up ring
30. Preformed packing
31. Lockwasher

Figure 4-40. Winch brake (hulls 8500-8519).

d. Cleaning, Inspection, and Repair.

(1) Clean all parts with solvent (FED. SPEC. PD-680) and dry thoroughly. When cleaning bearings, turn them by hand only.

(2) Replace all gaskets, packings, and seals exposed during disassembly.

(3) Check that ball and needle bearings turn smoothly and freely when rotated by hand. Inspect balls, needles, and races for visible damage.

(4) Check that gear teeth are smooth, show normal tooth-contact, and are free from chips, cracks, pits, and excessive wear. If any gear teeth

are damaged, check teeth of mating gear thoroughly for similar damage. Smooth out minor irregularities in gear teeth with fine polishing stone or wheel. Replace any gear that is broken or excessively worn.

(5) Check that gear shafts are true and free from nicks, grooves, and scoring. Minor scratches may be smoothed out with fine abrasive cloth or stone except on bearing surfaces. If bearing surfaces are damaged, gear must be replaced.

(6) Check shaft keys for tight fit in corresponding keyways in both the shafts and gears. Replace if loose.

(7) Check condition of driving and driven plates. Replace plates if excessive wear is apparent on teeth or on friction faces. Smooth out minor nicks or scratches. Check condition of piston seals and sealing surfaces. Clean up minor scoring and remove nicks and sharp edges from grooves.

(8) Weld broken gear cases and covers, using standard welding techniques, provided that repair can be made without misaligning bearing or shaft supporting members. Any broken part that could affect gear or shaft alignment when repaired must be replaced.

e. Lubrication.

(1) Lubricate hydraulic system seals and packings liberally with hydraulic oil before assembling.

(2) Lubricate gear reducer and winch bearings, gears, shafts, and seals liberally with SAE 90 gear lubricant before assembling. Lubricate bearing in winch support pedestal after assembly with waterproof anti-friction bearing grease. Lubricate until grease is visible outside seal on winch shaft. Fill gear reducer after assembly with SAE 90 gear lubricant to oil level plug on side of gear case.

f. Reassembly.

(1) Reassemble in the reverse order of disassembly. Use the following torque values:

Thread Size	*Torque Range* (inch-pounds)
10-32	20-25
¼-20	50-70
¼-28	50-70
5/16-18	70-90
3/8-16	160-185
7/16-14	235-255
½-13	400-480
9/16-12	500-700
5/8-11	700-900
¾-10	1150-1600

(2) Observe the following precautions during reassembly:

(a) Use a seal expanding tool when sliding oil seals over shafts.

(b) Be especially careful when installing cluster gear shafts in gear reducer to avoid damaging preformed packings as they pass through needle bearings inside gears.

(c) Install oil seal in winch support pedestal with lip toward winch to keep dirt, water, and other foreign material from entering the bearing.

g. Installation. Install the winch (para 2-9).

4-17. Winch - Hulls 8520 thru 8560 and 8580 thru 8618.

a. Description.

(1) The Gearmatic hydraulic winch consists of a primary drive housing and a final drive housing fastened to a winch base by dowel bolts which hold the housings concentric. The winch barrel is carried on anti-friction bearings between the drive housings (fig. 4-41).

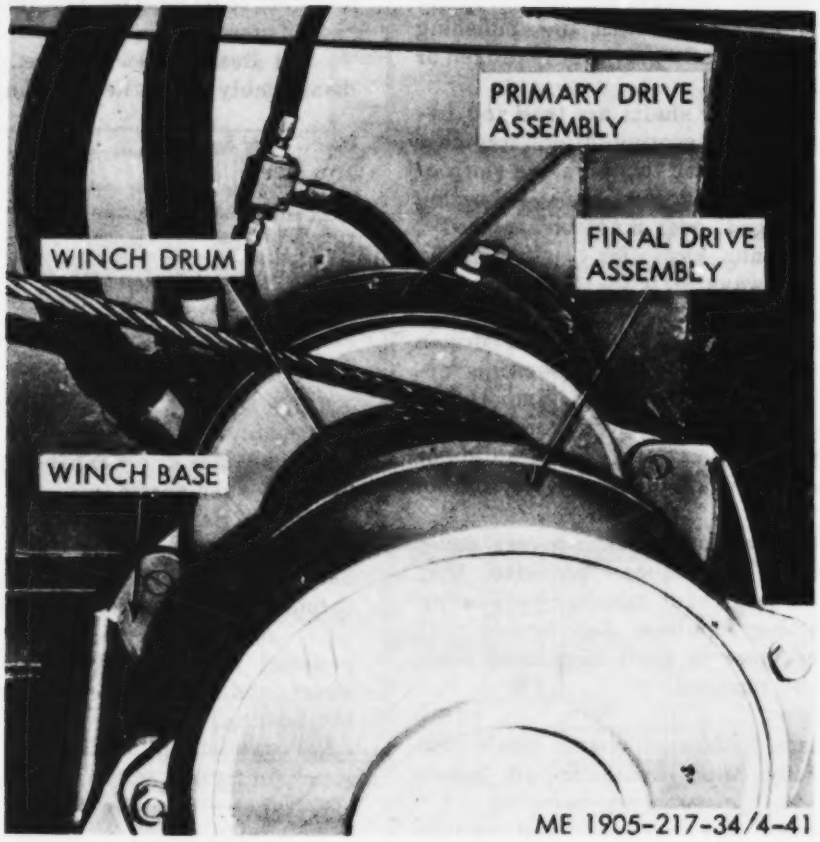


Figure 4-41. Winch (hulls 8520-8560 and 8580-8618).

(2) The primary drive housing contains a hydraulic motor which drives the sun gear of a primary planetary reduction. The output of this reduction is transmitted by a shaft which passes through the center of the winch barrel to the sun gear of a final planetary reduction in the final drive housing. The output from the final planetary reduction is transmitted directly to the winch barrel through a spline attaching the final drive planet hub to the winch barrel.

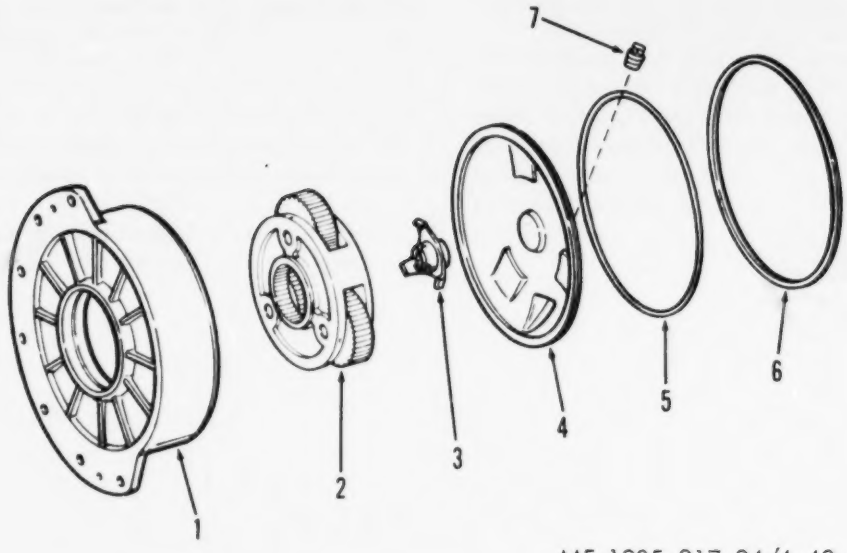
(3) The internal gear of the primary reduction is held in its drive housing by a metallic friction disc-type brake. The brake is held engaged by springs, and is released by an annular hydraulic cylinder. This cylinder is connected to that motor port which is pressurized for reverse rotation, and becomes the exhaust port for forward rotation. In this way the brake is engaged at all times until the winch is powered in reverse.

b. Removal. Remove the winch (para 2-9).

c. Disassembly.

(1) Disassembly of final drive assembly.

(a) Remove retaining ring (6, fig. 4-42).



ME 1905-217-34/4-42

1. Final housing
2. Final planet assembly
3. Thrust plate
4. End cover
5. Preformed packing
6. Retaining ring
7. Pipe plug

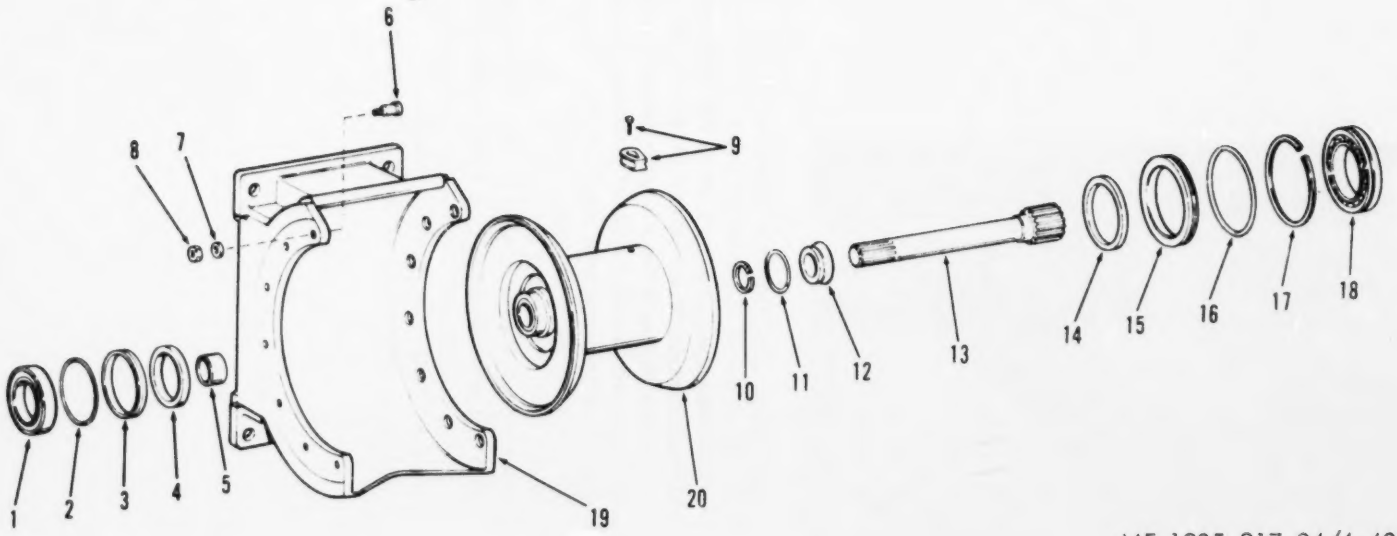
Figure 4-42. Winch final drive assembly (hulls 8520-8560 and 8580-8618), disassembly and reassembly.

(b) Remove the end cover (4) using a heel bar under the lug provided below the filler plug boss. Remove the discard preformed packing (5) from the end cover (4).

(c) Remove the thrust plate (3) from the final planet assembly (2).

(d) Using two pinch bars under the rim of the planet hub and against the end of the final housing (1) pull the final planet assembly (2) off the splined end of the drum. Care must be taken not to damage the pilot bore in the final housing (1) that carried the end cover (4).

(e) Remove the sun gear shaft (13, fig. 4-43) and remove the discard preformed packing (11) from the sun gear shaft.



1. Ball b ng
2. Preform d packing
3. Small seal ring
4. Oil seal
5. Drum bushing
6. Dowel bolt
7. Lockwasher
8. Hex, nut
9. Hondu
10. Snap ring
11. Preformed packing
12. Taper seal ring
13. Sun gear shaft
14. Oil seal
15. Large seal ring
16. Preformed packing
17. Snap ring
18. Ball bearing
19. Winch base
20. Drum

Figure 4-43. Drum and winch base assembly (hulls 8520-8560 and 8580-8618), disassembly and reassembly.

(f) Remove the seven nuts (8) and washers from the final drive end of the winch.

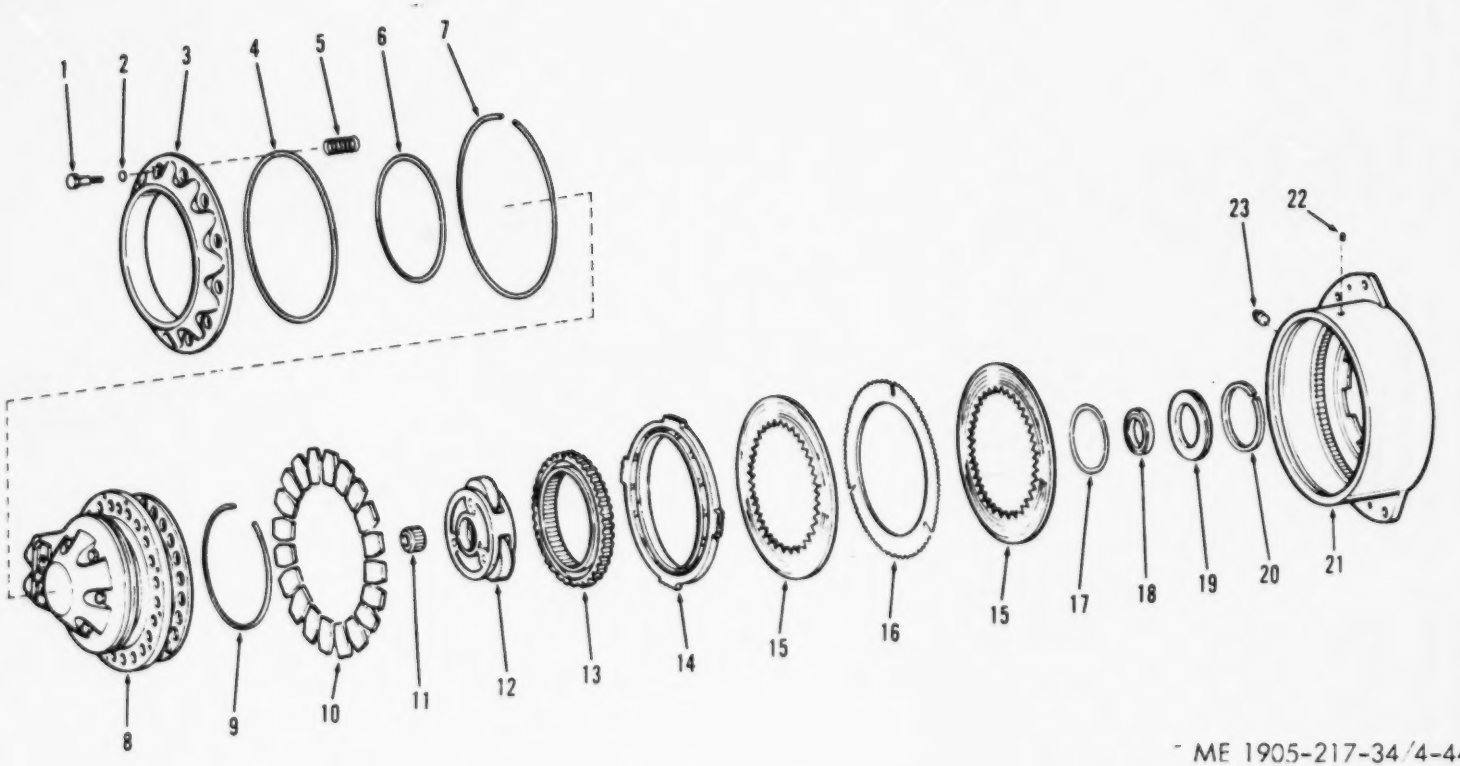
(g) For final housing with tapped puller holes in the flange, use two ½ inch N.C. x 2 inch cap screws as jacks and pull the housing off the dowel bolts (6). For final housings with cast slots under the edge of the flange, use two heel bars and remove the housing from the dowel bolts (6).

(2) Disassembly of primary drive assembly.

CAUTION

Do not remove this assembly as a unit as damage may be caused to the seal diameter of the primary planet hub and the tapered seal diameter of the taper seal ring on the sun gear shaft.

(a) Clean all dust and dirt away from the motor ports and vent port and disconnect the hydraulic hoses. Mark the location of the spring cover (3, fig. 4-44) with respect to the housing (21) and location of spring cover (3) with respect to the motor assembly (8), this will insure that the motor ports and vent port are located correctly on reassembly.



1. Capscrew
2. Seal washer
3. Spring cover
4. Preformed packing
5. Brake spring
6. Preformed packing
7. Snap ring
8. Motor assembly
9. Retainer
10. Segment
11. Primary sun gear
12. Primary planet assembly
13. Ring gear
14. Backing plate
15. Brake plate
16. Divider plate
17. Preformed packing
18. Oil seal
19. Seal ring
20. Snap ring
21. Primary housing
22. Pipe plug
23. Pipe plug

Figure 4-44. Primary drive assembly (hulls 8520-8560 and 8580-8618), disassembly and reassembly.

(b) Drain the oil from the primary housing (21) by removing one capscrew (1) with its seal washer (2) from the lowest point of the spring cover (3). Remove one pipe plug (22) from the top of the housing (21) to allow air to enter the housing.

(c) Remove the spring cover (3) using the following procedure. Remove the remaining cap screws (1) with washers (2) by slackening each cap screw (1) half a turn at a time, progressively around in a clockwise or counterclockwise direction. Care must be used to insure that the spring cover (3) is removed evenly as it carries the full spring load for the brake. When all the spring load has been removed from the spring cover (3) it can be withdrawn from the winch.

(d) Remove and discard preformed packing (4) from the spring cover (3).

(e) In most cases there will be a spring in every hole, but in certain applications fewer springs are required and it is important that they be located symmetrically when they are replaced. Note and mark any hole that does not contain a spring and then remove all the springs.

(f) Remove and discard the preformed packing (6) from the motor assembly (8).

(g) Remove snap ring (7) and motor assembly (8). Gearmatic tool No. B 13009 can be used to remove the motor assembly (8).

(h) The primary sun gear (11) may have been removed with the motor assembly (8) in step g. If not, remove the primary sun gear (11) from the bore of the primary planet assembly (12).

(i) Remove the retainer (9) from inside of the segments (10), then remove the segments (10) from the primary housing. Before removing the primary planet assembly (12), first remove the sun gear shaft. See instructions for the final drive assembly ((1) (e) above).

(j) When the sun gear shaft has been removed, remove the primary planet assembly (12).

(k) Remove the remaining parts in sequence as shown by the item numbers (13) thru (23).

(l) Remove the nuts (8, fig. 4-43) and washers (7) that attach the primary drive housing (21, fig. 4-44) to the winch base (19, fig. 4-43).

(m) If the final drive assembly has already been removed from the winch base, remove the drum (20, fig. 4-43). Support the drum under the center of the barrel, and drive it off the primary housing by tapping the inside face of the drum flange opposite to the primary housing.

(n) If the final drive assembly has not been removed, remove the primary housing as follows: For primary housings with tapped puller holes in the flange, use two ½ inch N.C. x 2 inch cap screws as jacks and pull the housing off the dowel bolts (6). For primary housings with cast slots under the edge of the flange, use two heel bars and remove the housing from the dowel bolts.

(3) Disassembly of drum bearings and seals.

(a) Remove bearing (1, fig. 4-43) from the drum (20) using a special puller to grip in the groove provided in the O.D. of the bearing. Support the puller screw on a plug located in the bore of the drum. Gearmatic tool No. C 13115 can be supplied for removing this bearing.

(b) Remove the small seal ring (3) which contains oil seal (4) and preformed packing (2). Remove and discard the preformed packing and the oil seal.

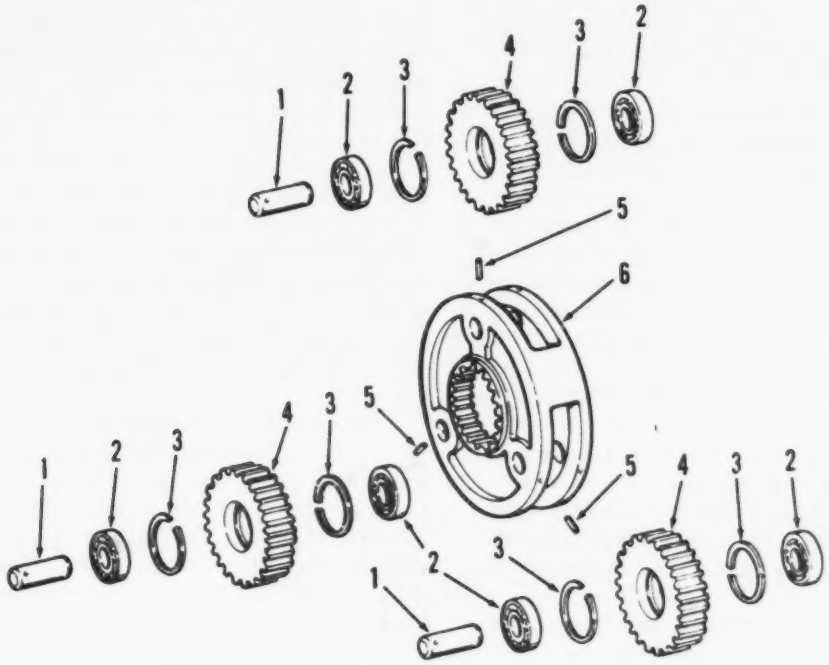
(c) Remove the drum bushing (5) with a bearing puller only if it requires to be replaced.

(d) To remove bearing (18) first remove the snap ring (17) from its O.D. Using the same puller as used above, place a plug located in the bore of the drum and pull the bearing by gripping in the snap ring groove on the O.D. of the bearing.

(e) Remove the large seal ring (15) which contains oil seal (14) and preformed packing (16). Remove and discard the preformed packing and the oil seal.

(4) Disassembly of final planet assembly.

(a) Using a ¼ inch diameter pin punch, drive pin (5, fig. 4-45) completely into the final planet pin (1).



1. Final planet pin
2. Ball bearing
3. Snap ring
4. Final planet gear
5. Pin
6. Final planet hub

Figure 4-45. Final planet assembly (hulls 8520-8560 and 8580-8618), disassembly and reassembly.

(b) Remove the final planet pin (1) by tapping it out of the planet hub (6) so that it is removed from the splined bore side of the planet hub. Remove pin (5) from the planet pin (1).

(c) Now remove the planet gear (4).

(d) Drive the ball bearings (2) out of the planet gear (4) using a drift. Remove the snap rings (3) only if they are to be replaced because of damage.

(5) Primary planet assembly (12, fig. 4-44). Replace as an assembly. Disassembly by direct support or general support personnel is not recommended.

(6) Motor assembly (8, fig. 4-44). Replace as an assembly. Disassembly by direct support or general support is not recommended.

d. Cleaning, Inspection, and Repair.

(1) Inspection of final drive assembly.

(a) Wash all parts in a solvent (FED. SPEC. PD-680) and dry thoroughly with compressed air or clean cloths.

CAUTION

Do not dry the final planet assembly with compressed air, as this may drive particles of dirt into the ball bearings which carry the planet gears.

(b) Check for wear at the center of the thrust plate (3, fig. 4-42). The original thickness at the center of the thrust plate was 1.363 inches, if the wear is greater than 3/32 inch replace the thrust plate.

(c) Check that the planet gears run freely in the final planet assembly (2).

(d) Inspect the gear teeth in the final housing (1). If wear is greater than .015" when compared to the unworn part of the teeth, replace the final housing (1). Check the large pilot bore at the end of the final housing (1) used to carry the end cover (4). Remove all roughness and scores carefully using a scraper and extra fine emery cloth so that preformed packing (5) will seal on this diameter.

(e) Inspect the sun gear shaft (13, fig. 4-43). Check the gear teeth for wear by comparing the tooth-thickness at the worn area of the teeth with the tooth-thickness at the unworn end. If the wear is grater than .012 inch replace the sun gear shaft.

(f) Inspect the taper seal ring (12), if the tapered diameter has any roughness or scratches remove the tapered seal ring from the shaft by using a punch between the gear teeth to drive the ring off the shaft. Replace with a new taper seal ring.

NOTE

If any one of the gears in this assembly requires replacement because of tooth wear, all gears in the assembly should be replaced.

(2) Inspection of primary drive assembly.

(a) Place the primary planet assembly (12, fig. 4-44) to one side and wash all other parts in solvent (FED. SPEC. PD-680). Dry thoroughly with compressed air or clean cloths. Do not wash the primary planet assembly unless it is faulty and requires to be replaced or disassembled.

(b) Inspect the bore in the spring cover (3) for scores or bruises. If possible smooth out scores or bruises with a scraper and extra fine emery cloth in order that preformed packing (6) will seal effectively.

(c) Check snap ring (7) for flatness and that it forms a true circle, if bent or damaged replace.

(d) Inspect the retainer (9) for distortion. Be sure that it seats properly all around the bottom of the groove in the bore of the segments (10). Check the segments (10) for flatness, replace with new parts if bent or distorted.

(e) Check that the planet gears in the primary planet assembly (12) will rotate freely and smoothly in one direction and that they will all "lock up" in the opposite direction. If any of the gears will not lock instantly in the "lock up" direction or if there is the slightest slippage in this direction, replace the assembly.

(f) Inspect the teeth in the ring gear (13). Replace if wear is excessive.

(g) Inspect the backing plate (14) for wear on the friction face. If the wear exceeds 1/16 inch replace with a new part. The original thickness was .627 inch at the thickest point. Check the external teeth for wear. If wear is excessive replace with a new part.

(h) Inspect the friction surfaces of the brake plates (15), if wear has removed the grooves, replace the plates.

(i) Check divider plate (16) for wear and distortion. If wear is excessive or if the plate is buckled or does not form a true circle replace with a new part.

(3) Inspection of drum and bearings (fig. 4-43).

(a) Wash all parts in solvent (FED. SPEC. PD-680) and dry thoroughly using compressed air or clean cloths.

CAUTION

Do not dry or spin the bearings with compressed air. Allow the bearings to air dry after they are properly cleaned.

(b) Check the seal diameters at each end of the drum (20) for rust or roughness. Clean and polish the seal diameters using extra fine emery cloth. Check the bearing hub diameters for scores and wear. If there is any wear, possibly caused by a seized bearing, the drum will require to be replaced.

(c) Inspect the seal face in the bore of the drum (20) at the splined end. This face must have a smooth finish and be free from scratches, etc. Polish if necessary with extra fine emery cloth. If this surface is damaged the drum will require to be replaced.

(d) Inspect the drum bushing (5) for bruises, scores and wear. Remove all high spots from bruises or scores using a scraper. The original inside diameter of this bushing was 2.190 inches. If wear is greater than .010 inch in diameter, remove the bushing and replace it with a new part.

(e) Inspect the ball bearings (1) and (18) for wear and pitting at the balls and ball grooves. Replace bearings if worn or pitted.

(4) Inspection of final planet assembly (fig. 4-45).

(a) Wash all parts in solvent (FED. SPEC. PD-680) and dry thoroughly using compressed air or clean cloths.

CAUTION

Do not dry the ball bearings with compressed air. Allow them to air dry after they are properly cleaned.

(b) Inspect the planet pin bores in the planet hub (6) for scores or bruises which may have been caused in removing the planet pins. Remove the high spots of any scores or bruises carefully with a scraper, sufficiently to allow a planet pin to be pressed into each bore by hand.

(c) Inspect the planet pin (1) for excessive wear at the bearing area. If wear exceeds .001 inch on the diameter the pin should be replaced.

(d) Check the planet gears (4) for wear and damage on the gear teeth. If wear is excessive replace the planet gears. Inspect the ball bearings (2) for wear and pitting at the balls and ball grooves. Replace bearings if worn or pitted.

e. Reassembly.

(1) *Assemble bearings and seals to drum.*

(a) Install oil seal (4, fig. 4-43) in the small seal ring (3) so that the lip of the oil seal is at the end of the seal ring farthest from the preformed packing groove. Lubricate preformed packing (2) with grease and install it in the groove on the outside diameter of the seal ring. Lubricate the oil seal, give the preformed packing an additional coat of grease, and install this seal assembly on the non-splined end of the drum (20) so that the lip of the oil seal is towards the drum. Be careful not to damage the lip of the oil seal as it is pressed over the taper of the seal diameter of the drum. Pack the seal with grease around the seal diameter of the drum.

(b) Install oil seal (14) in the large seal ring so that the lip of the seal is at that end of the seal ring which has the projecting diameter at the bore. Lubricate preformed packing (16) with grease and install it in the groove on the outside of the seal ring. Lubricate the oil seal, give the preformed packing an additional coat of grease and install this assembly on the splined end of the drum (20) so that the lip of the oil seal is towards the drum. Be careful not to damage the lip of the oil seal as it is pressed over the taper on the seal diameter of the drum. Pack the seal with grease around the seal diameter of the drum.

(c) Install bearing (1) on the non-splined end of the drum (20) so that the groove on the outside diameter of the bearing is installed towards the drum. Pack the bearing thoroughly with good quality ball bearing grease.

(d) Install bearing (18) on the splined end of the drum (20) so that the snap ring on the outside diameter of the bearing is installed towards the drum.

(e) Install the hondu (9) in its slot in the drum (20) so that the small end of the hondu enters the wide end of the slot.

(f) Press bushing (5) into the drum (20) using a sizing mandrel that is 2.1885 inch diameter. Install the bushing so that the end of the bushing is flush with the end of the drum. Gearmatic tool No, B 1397 can be used to install this bushing.

(2) *Assemble winch.*

(a) Place the winch base (19, fig. 4-43) on the work bench so that the side which is to be the final drive end of the winch is facing up.

(b) Attach the final housing (1, fig. 4-42) to the winch base using seven dowel bolts (6, fig. 4-43) washers (7) nuts (8).

(c) Turn this assembly over so that it rests on the end of the final housing. Now take the drum (20) which has previously been assembled with the seal and bearings and pilot the bearing on the splined end of the drum into the bore of the final housing. Tap the drum assembly down until the snap ring on the bearing at the splined end of the drum is properly seated on the end of the final housing bore. There will be approximately 1/16 inch clearance between the final housing and the end of the drum flange when the bearing snap ring is seated.

(d) Take the primary housing (21, fig. 4-44) and install snap ring (20) in the snap ring groove that is closest to the large open end of the housing. Now pilot the primary housing over the bearing, on the plain end of the drum (non-splined end) so that the dowel bolts (6, fig. 4-43) will locate in the flange of the primary housing. Tap the primary housing on until its flange contacts the winch base using seven washers (7) and nuts (8) on the dowel bolts (6).

(e) Torque load nuts (8) to 75 ft. lbs.

(3) *Assemble primary drive assembly.*

(a) Set the partly completed winch on end so that it rests on the end of the final housing. Check that the drum bearing which is carried in the primary housing has been thoroughly packed with grease.

(b) Lubricate perfórmed packing (17, fig. 4-44) with grease and install it in its groove in the seal ring (19). Give the preformed packing an additional coat of grease and install the seal ring (19) in the bore of the primary housing so that the countersunk seal face is out towards the open end of the housing (21). Tap the seal ring (19) into place with a soft hammer so that it locates against the snap ring (20) which was previously installed.

(c) Install the primary planet assembly (12) so that the projecting boss locates in the bushing (5, fig. 4-43) at the end of the drum. When this assembly is in place rotate it by hand to make sure that it is free to turn.

(d) Install the segments (10, figure 4-44) in the groove next to the internal teeth in the primary housing (21). Install the retainer (9) in the groove formed on the inside of the segments (10), so that the ends of the retainer (9) rest in center of one of the segments.

(e) Install the primary sun gear (11) in the primary planet assembly (12) so that the teeth on the O. D. engage with the gears in primary planet assembly (12).

(f) Take the motor assembly (8) and place it on the work bench with the motor shaft end up. Check that the brake piston is located 7/16 inch away from the gear housing. If necessary, tap the brake piston down with a soft hammer, or pry it up by using two heel bars until the 7/16 inch gap is obtained.

(g) Install the motor assembly (8) in the primary housing (21) by holding it square with the end of the primary housing as it enters the

housing. The spline at the end of the motor shaft will engage with the gear in the primary planet assembly (12) and the motor will pilot into the planet hub bushing. It may be necessary to rotate the motor assembly (8) slightly so that the spline at the end of the motor shaft will engage with the gear (11) in the primary planet assembly (12). The motor assembly will assemble into the primary housing easily by tapping the outside of the motor assembly lightly with a copper drift until the snap ring (7) can be installed. Do not use force to install the motor assembly (8). If there is interference remove the motor assembly and investigate.

(h) Once the motor assembly (8) is in place install snap ring (7) and make sure that it is properly seated in the bottom of the snap ring groove all the way around the housing (21). When snap ring (7) has been installed, rotate the motor assembly in the primary housing to locate the motor ports at the required angle for the particular installation.

(i) Lubricate preformed packing (6) with grease and install it in its groove on the motor assembly (8). After the preformed packing is installed lubricate it again with grease.

(j) Install the brake springs (5) in the same symmetrical pattern as they were in before disassembly. In most cases there will be a spring for every hole but in some installations fewer springs are used and it is important that the springs be installed in a symmetrical pattern for an even load on the brake.

(k) Lubricate preformed packing (4) with grease and install it in its groove in the spring cover (3). Once the preformed packing is installed lubricate it again.

(l) Install the spring cover (3) over the motor assembly so that the vent port is located in the correct position for the particular installation.

(m) Install cap screws (1) with washers (2). Screw in all the cap screws to be finger tight and then tighten them evenly by one half turn at a time progressively around in a clockwise or counterclockwise direction. Care must be used to insure that the spring cover (3) remains parallel to the end of the primary housing (21) as it is tightened into place. Torque load the cap screws to 50 foot pounds.

(4) *Assemble the final planet assembly.*

(a) Install the snap rings (3, fig. 4-45) in the groove in the bore of the planet gear (4). Press the ball bearings (2) into the final planet gear (4) so that the ends of the bearings shoulder against the snap rings (3).

(b) Place the final planet gear (4) into the final planet hub (6) so that the bore of the bearing lines up with a planet pin hole.

(c) Install a final planet pin (1) in the final planet hub (6) so that it passes through the ball bearings (2) in the planet gear and the drilled hole in the final planet pin lines up with the hole in the rim of the final planet hub.

(d) Install pin (1) and using 3/16 inch diameter pin punch, drive the pin in until the outer end of the pin is 7/16 inch below the outside diameter of the final planet hub (6).

(e) Repeat the above for the remaining two final planet gears (4) and check that all the gears run freely.

(5) Assemble the final drive assembly.

(a) Lubricate preformed packing (11, fig. 4-43) with grease and install it over the taper seal ring (12) which is installed on the sun gear shaft (13).

(b) Check that the snap ring (10) is in place on the sun gear shaft (13) and install the sun gear shaft in the winch so that it engages in the splined bore of the primary planet hub. Slide the sun gear shaft (13) in until the snap ring (10) contacts the end of the primary planet hub, at the same time preformed packing (11) will contact the seal face on the end of the drum and be pushed up the tapered diameter of the tapered seal ring (12).

(c) Install the final planet assembly (2, fig. 4-42) so that the planet gears engage in the internal teeth of the final housing (1) and the splined bore of the planet hub locates over the splined end of the drum. Tap the planet assembly (2) into place until it contacts the bearing that carries the drum in the final housing (1).

(d) Install the thrust plate (3) in the end of the final planet assembly (2).

(e) Lubricate preformed packing (5) with grease and install in its groove in the end cover (4). Give the preformed packing an additional coat of grease and install the end cover in the final housing (1) so that the filler boss will be located at the bottom of the final housing when the winch is mounted. Make sure that the end cover is properly seated against the end of the gear teeth in the final housing.

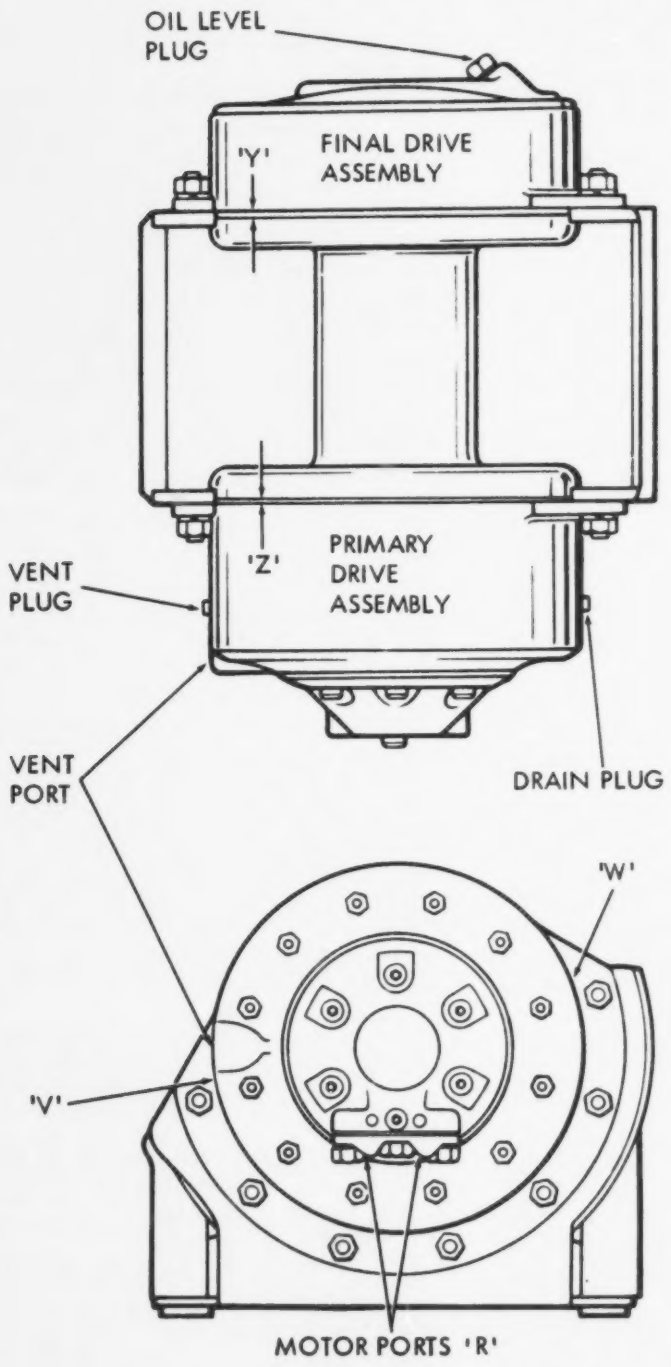
(f) Install the retaining ring (6) and make sure that it is properly seated in the bottom of the retaining ring groove all the way around the housing (1).

(g) Fill the final housing (1) with SAE 90 transmission oil to the level of the filler hole and install the filler plug (7).

(6) *Winch alinement.*

(a) When the assembly of the winch has been completed and secured to its mounting base, check the alignment of the winch according to the instructions in the following paragraph.

(b) Measure clearance (Y, fig. 4-46) with feeler gages at points "V" and "W" as indicated. Also measure clearance "Z" at points "V" and "W". For good alinement, clearance "Y" should be equal when measured at points "V" and "W" within .005 inch. Clearance "Z" should also be equal when measured at "V" and "W" within .005 inch. Clearance "Y" does not require to be equal to clearance "Z". If the clearances measured at "V" and "W" are not within .005 inch, install shims under corner of the winch base until clearances "V" and "W" are within .005 inch when the winch is bolted solidly to its mounting.



ME 1905-217-34/4-46

Figure 4-46. Winch alinement.

(c) Run the winch in the reverse rotation, before running it in the forward rotation. This will centralize the ring gear (13, fig. 4-44) which is held in place by the brake plates (15).

f. Installation. Install the winch (para 2-9 *b*).

4-18. Ramp Hoist Hydraulic Pump

a. General. Refer to (para 4-11 *a*) for location and identification of the ramp hoist hydraulic pump.

b. Removal. Remove the pump (para 4-11 *b*).

c. Disassembly and Repair.

NOTE

Identify parts during disassembly for reassembly in proper relationship.

(1) Remove four cover bolts (26, fig. 4-47) and cover (24). Note relative position of inlet port in cover to the outlet port in body for correct assembly.

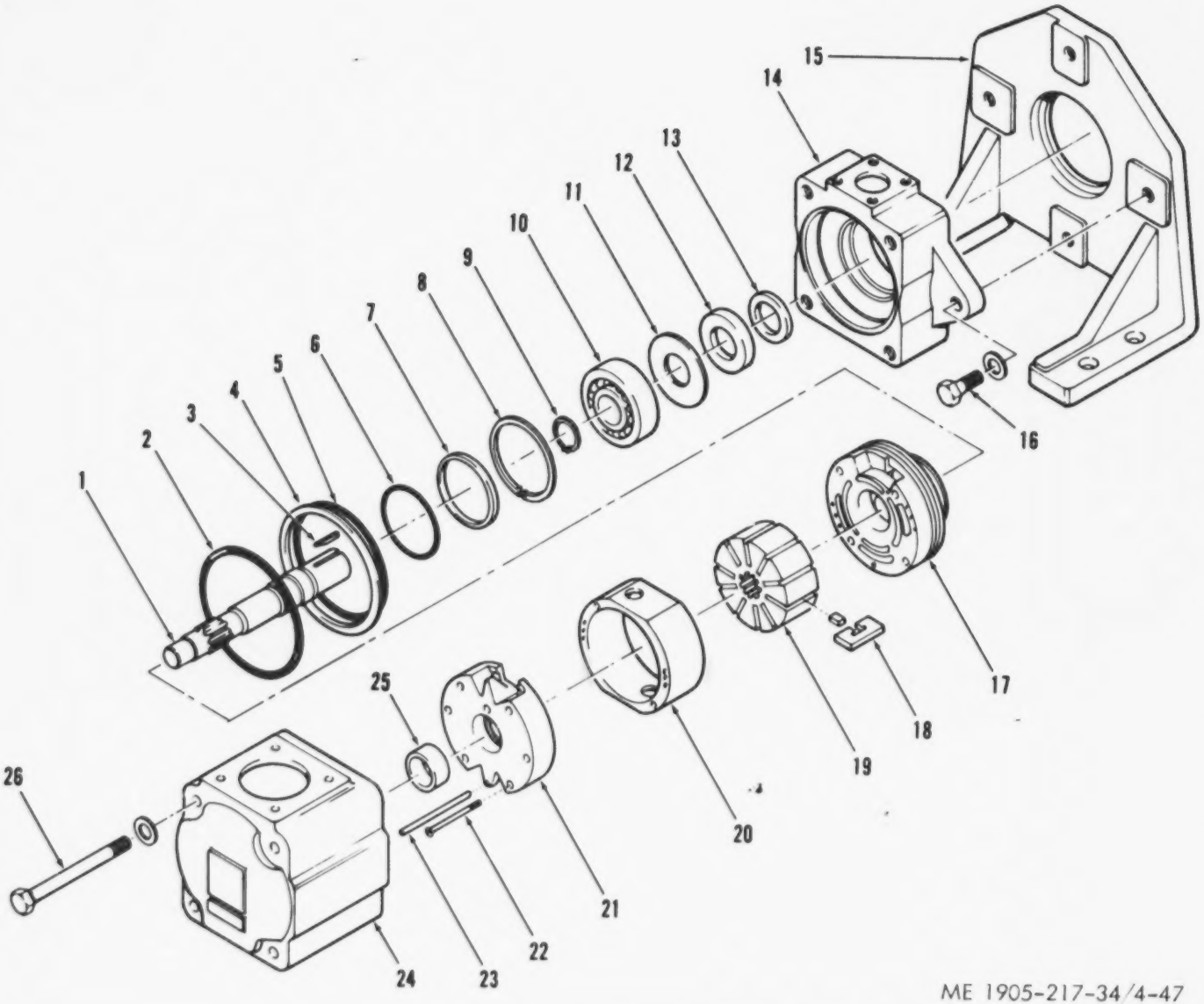


Figure 4-47. Ramp hoist pump, exploded view.

Key to figure 4-47.

1. Drive shaft
2. O-ring
3. Woodruff key
4. Backup ring
5. O-ring
6. Preformed packing
7. Backup ring
8. Snap ring
9. Bearing retainer ring
10. Bearing
11. Washer
12. Oil seal
13. Felt seal
14. Pump body
15. Pump mounting bracket
16. Bolt
17. Pressure plate
18. Vane and insert
19. Rotor
20. Ring
21. Wear plate
22. Screw
23. Location pin
24. Pump cover
25. Bushing
26. Cover bolt

(2) Grasp the pump cartridge (inner assembly) and while turning, pull it from the drive shaft. Loosening of the pump cartridge can be accomplished by prying under the flats of the ring with two screw-drivers.

(3) Remove large O-ring (2) from recess in body.

(4) Remove O-rings (5, 6) and backup rings (4,7) from hub and outside diameter of pressure plate (17).

(5) Remove two screws (22) from face of wear plate (21). Lift wear plate from locating pins (23) and remove pins.

(6) Remove ring (20) from around the rotor (19).

(7) Remove vanes and inserts (18) from rotor and remove rotor from the pressure plate.

(8) Wash and dry all cartridge parts.

(9) Inspect surfaces of wear plate, pressure plate, ring and rotor for scoring and excessive wear. Light scoring may carefully be stoned or lapped. Discard parts that are heavily scored. Check edges of vanes for wear. Vanes shall not have excessive play in rotor slots or burrs on edges. Inspect inside diameter of bushing (25). Remove bushing if wear or scoring is evident. If wear plate is to be replaced, do not remove bushing as a new plate comes with bushing inserted.

(10) Lift out shaft key (3) from its seat in shaft. Remove bearing retaining ring (9) and fully remove drive shaft and bearing (10) from body by gently tapping the keyed end of shaft with a soft hammer.

(11) Check the bearing for wear before removing it from the shaft. Rotate bearing, applying a little pressure to the outer race, to determine whether the balls or races have become pitted, galled or cracked. Check for looseness. If in doubt, remove bearing from shaft at the point of contact with bushing and sealing lip of shaft oil seal. If excessive scoring or wear is noted, replace shaft.

(12) Remove washer (11) from bore in body. Using a suitable hooked tool or a drift, remove shaft oil seal (12) and felt seal (13) from body.

d. Reassembly.

(1) Lubricate replacement parts before assembly with clean hydraulic fluid.

(2) Install a new felt seal and shaft oil seal in counterbore of body. Soak both seals thoroughly in hydraulic oil before installing. Make sure that lipped edge of seal is toward inside of body. Use a suitable drift that will not damage the seal during installation. Lubricate the shaft oil seal journal with petroleum jelly.

(3) Position shaft bearing in place on drive shaft, being careful not to cock the bearing. Use arbor press, support the inner race of the bearing and press the bearing against the shoulder of the craft. Apply tape around the end of shaft to protect the seal. Install shaft and bearing into the body until the bearing is fully seated. If necessary, gently tap the shaft with a soft hammer.

(4) Install shaft snap ring and bearing retaining ring. Make sure that both parts are firmly seated in place.

(5) Install the shaft key at this time or after the pump has been completely reassembled.

e. Pump Cartridge Reassembly.

(1) Install O-ring and backup ring in groove on hub diameter of pressure plate. Install a backup ring and O-ring around large step diameter of pressure plate. Make sure that smooth sides of backup rings face the sealing rings.

NOTE

Back-up rings must always be installed away from the pressure chamber. See figure 4-47.

(2) Position large O-ring in recess in body. Use petroleum jelly to hold O-ring in position during assembly of pump cartridge.

NOTE

Direction of rotation is designated as viewed from shaft end of pump. R. H. rotation is clockwise. L. H. rotation is counterclockwise.

(3) Place rotor on pressure plate with arrow pointing in desired direction of rotation. Install inserts in vanes and position both parts in rotor slots. The sharp edges of the vanes must be toward direction of rotation.

(4) Install locating pins in pressure plate. Install ring over locating pins against pressure

plate with arrow pointing in direction of shaft rotation. Lubricate rotor and ring with clean hydraulic oil.

(5) If wear plate bushing was removed, press a new bushing into wear plate bore. Install plate on locating pin against ring. Install two screws and tighten.

f. Cover End Reassembly.

(1) Carefully install pump cartridge on drive shaft and seat it firmly in place in the body.

(2) Install the cover making certain that the two locating pins fit into the holes inside the cover. Seat the cover firmly and secure in place with four cover bolts. The threads of the bolts should be oiled lightly and torqued to 85-95 ft. lbs.

(3) After the unit has been completely reassembled, pour a small quantity of clean hydraulic oil into the cover inlet port. Rotate drive shaft several turns by hand to check for free rotation and to make sure of complete lubrication of the cartridge parts. Cap the pump inlet and outlet ports to prevent entrance of foreign materials.

g. Installation. Install the pump (para 4-11 d).

4-19. Ramp Hoist Control Valve.

a. General. The control valve is a four-way directional valve with an inlet port, two motor ports, and an outlet port. The valve consists of a body incorporating a sliding spool, centering springs, and check valves. The inlet section contains a relief valve assembly which is set at 2000 psi. The control valve used on hull number 8500 thru 8519 is a Vickers CM2-NO2-R20B-L30 and the control valve used on hull number 8520 thru 8560 and 8580 thru 8619 is a Vickers CM3-NO2R20-BL-30. The two valves are similar except for size. Instructions in following paragraphs apply to both.

b. Removal. Remove the control valve (TM 55-1905-217-12, para 4-89).

c. Disassembly. See figure 4-48.

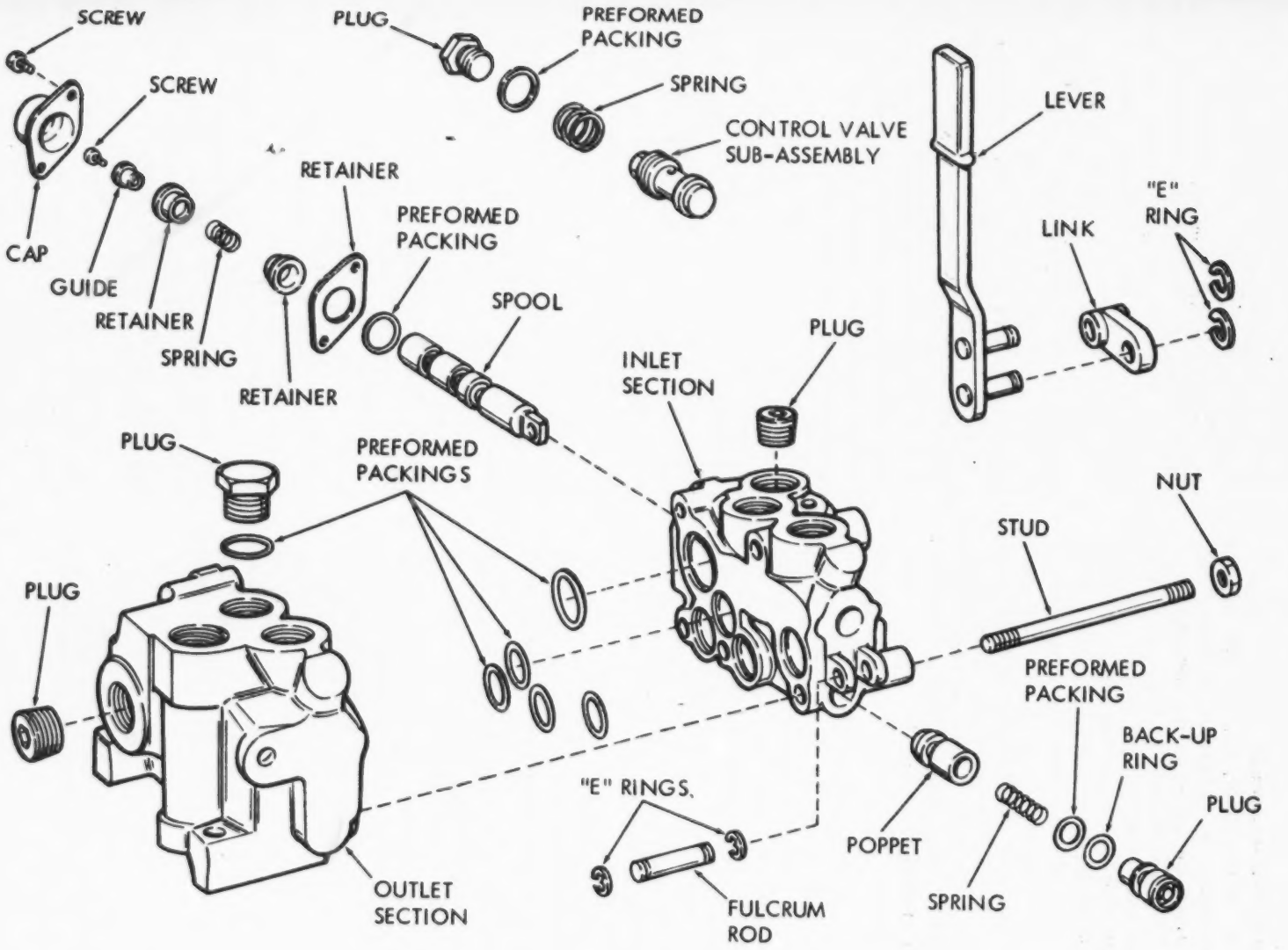


Figure 4-48. Ramp hoist control valve, disassembly and reassembly.

(1) *Parts Identification.* During disassembly, particular attention should be given to identification of parts for reassembly. Spools are selectively fitted to valve bodies and must be returned to the same bodies from which they were removed. Valve sections should be reassembled in the same order. If hand levers are used, remove the "E" rings which retain the fulcrum rod and remove the links, levers and retaining rings.

(2) *Attaching parts.* Remove the four tie studs and nuts and separate the valve sections. Be careful not to destroy or lose spacers.

(3) *End caps.* Remove the two screws which secure the spool and cap and remove the cap. Remove the preformed packing from the body.

(4) *Operating spool.* Slide the spool out of its bore from the cap end and remove the preformed packing from the valve body around the spool bore. Do not remove the centering spring and retainers unless it is necessary to replace them.

(5) *Check valve.* Grip the stem of the check valve plug with pliers and pull it out of the valve body. Remove the preformed packing and back-up ring. Remove the spring and poppet from the valve body.

(6) *Relief valve sub-assembly.* Screw out the plug which retains the relief valve and remove the preformed packing from the plug. Remove the spring and the relief valve sub-assembly.

(7) *Valve body.* Remove the plug and preformed packing from the blocked cylinder port on models with a single acting spool. If the alternate discharge port is plugged, it is not necessary to remove the plug unless the body is to be replaced.

d. Cleaning, Inspection, and Repair.

(1) Discard all old seals. Wash all parts in a clean mineral oil solvent and place them on a clean surface for inspection.

(2) Carefully remove burrs by light stoning or lapping. Be certain there is no paint or burrs on mating surfaces of valve bodies.

(3) Inspect the valve spools and bores for burrs and scoring. If scoring is not deep enough to cause objectionable leakage, the surfaces can be stoned or polished with crocus cloth. If scoring is excessive, the valve body and spool must be replaced by ordering a new section. Check the valve spool for freedom of movement in the bore.

(4) Check the relief valve for smooth movement in its bore. The valve should move from its own weight.

e. Reassembly.

NOTE

Coat all parts with clean hydraulic oil to facilitate reassembly and provide initial lubrication. Petroleum jelly can be used to hold seal rings in place on assembly.

(1) *Valve body.* On models with single-acting spool, install the preformed packing on the port plug and plug the appropriate cylinder port. Tighten the plug securely, but DO NOT over tighten.

(2) *Relief valve.* Install the preformed packing on the relief valve plug. Place the relief valve assembly in its bore, hex nut ends towards opening. Install the spring and plug and tighten the plug securely but DO NOT over tighten.

(3) *Check valve.* Install a new back-up ring and preformed packing on the check valve plug with the preformed packing toward the spring and poppet. Place the poppet and spring in the body and install the plug.

(4) *Operating spool.* If centering spring and spool have been removed, install new preformed packing in the preformed packing groove in the body at each end of the spool bore. Install spool in bore from the cap end. Install the flat retainer, guide and screw. Tighten the screw securely. Aline the flat retainer by shifting the spool. Spool bind is an indication of flat retainer misalignment. Install the end cap and attaching screws. Tighten the end cap screws securely.

(5) *Assembly of unit sections.*

CAUTION

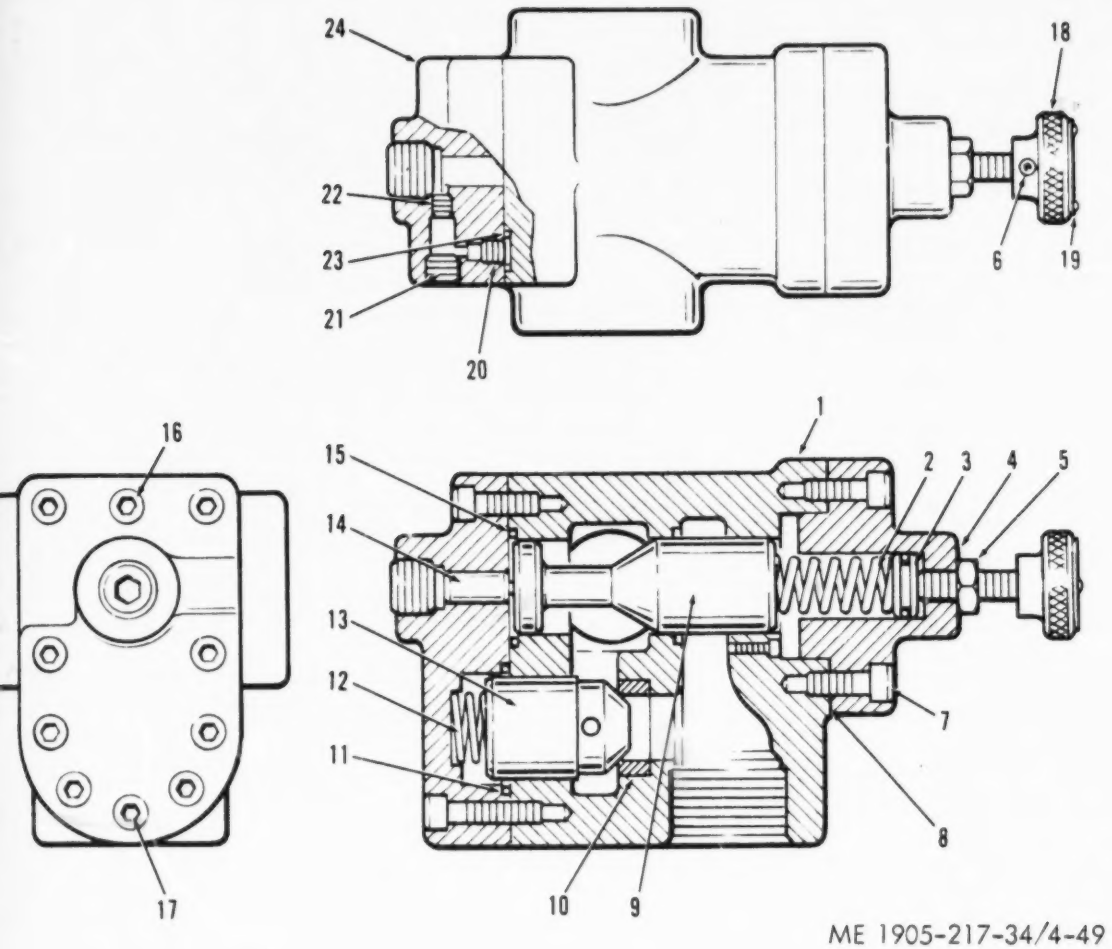
Make sure all mating surfaces of valve bodies are free of burrs and paint.

Install seal rings in the grooves in the body of each inlet and center section. Use petroleum jelly to hold the seals in place. For CM2 valves, install the spacers to insure against spool bind when the studs are tightened. With the mounting feet on a flat surface carefully place the sections together in the same order in which they were removed. The mounting feet must be maintained in a flat plane to prevent spool bind (due to body distortion) when the valve is mounted for operation. If levers are used, install pins in each spool and assemble the levers, fulcrum rod and "E" rings. Tighten nuts on CM 2 to 45-50 foot pounds torque and on the CM 3 to 55-60 foot pounds torque.

f. Installation. Install the control valve (TM-55-1905-217-12, para 4-89).

4-20. Ramp Hoist Counterbalance Valves

a. General. Landing craft with hull number 8500 thru 8519 have a Double A SA2-185-B-IT-K44 counterbalance valve and those with hull no. 8520 thru 8560 and 8580 thru 8618 have a similar valve Double A SA2-185D11/4 inches. The major difference is in the relief pressure provided. Figure 4-49 illustrates both valves.



1. Body
2. Spring
3. Spring follower
4. Top cap
5. Full nut
6. Socket set screw
7. Socket cap screw
8. Gasket
9. Spool
10. Seat
11. Preformed packing
12. Spring
13. Spool
14. Plunger
15. Preformed packing
16. Socket cap screw
17. Socket cap screw
18. Pressure adjusting screw
19. Drive screw
20. Socket pipe plug
21. Socket pipe plug
22. Orifice plug
23. Preformed packing
24. Bottom cap

Figure 4-49. Ramp hoist counterbalance valve, cross-section view.

b. Removal. Remove counterbalance valve TM 55-1905-217-12, para 4-94 and 4-96).

c. Disassembly and Repair.

(1) Refer to Figure 4-49 to disassemble and epair the counterbalance valve.

(2) Replace new gasket and packing. Replace ther defective parts as necessary.

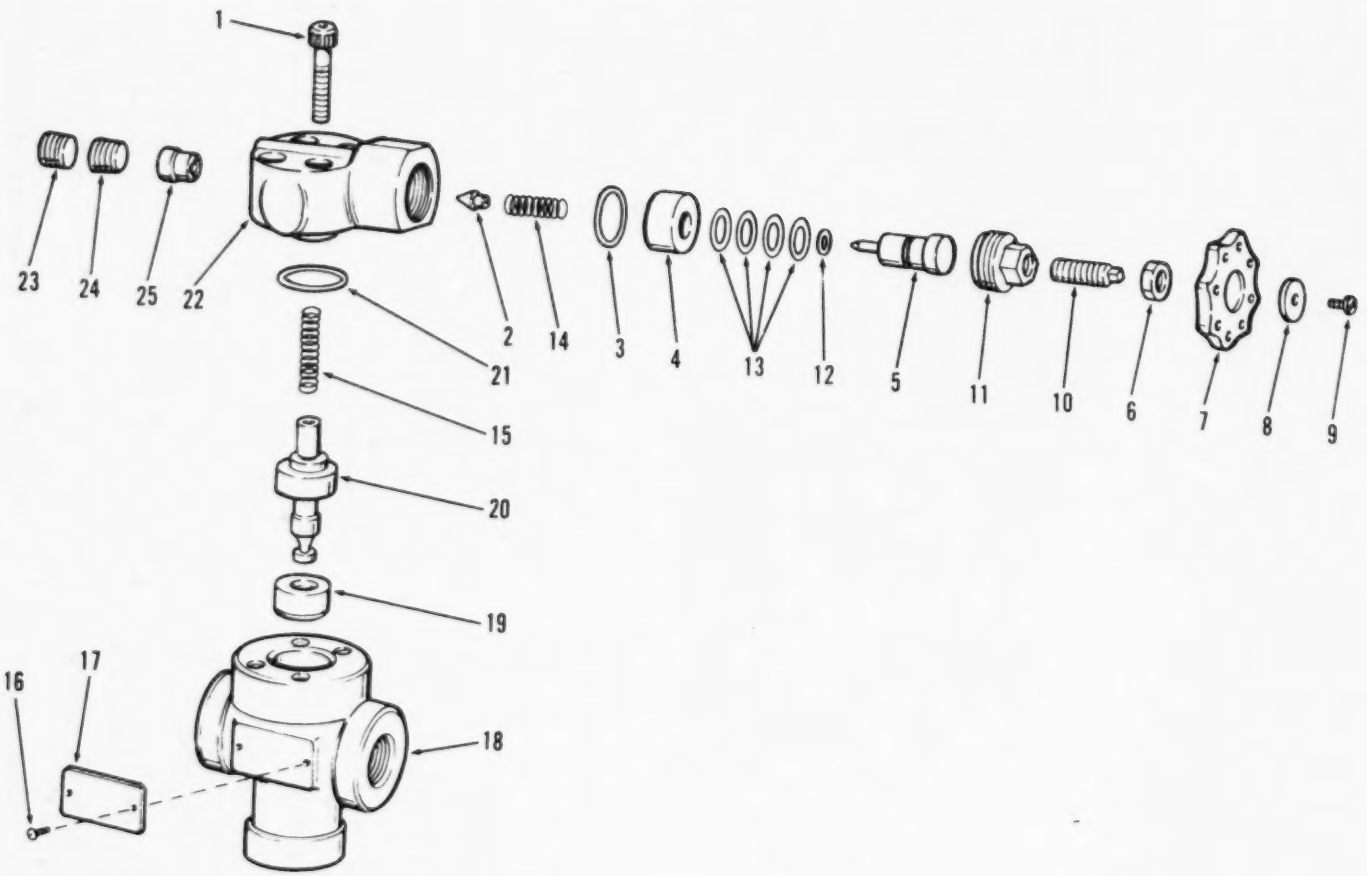
d. Installation. Install the counterbalance alve and adjust the pressure setting as rescribed in (TM-55-1905-217-12, para 4-94 and -96).

4-21. Ramp System Relief Valve

a. General. Refer to Operator and Organizations Maintenance Manual (TM 55-1905-217-12) for location and identification of the relief valve.

b. Removal. Remove the relief valve (TM 55-1905-217-12, para 93).

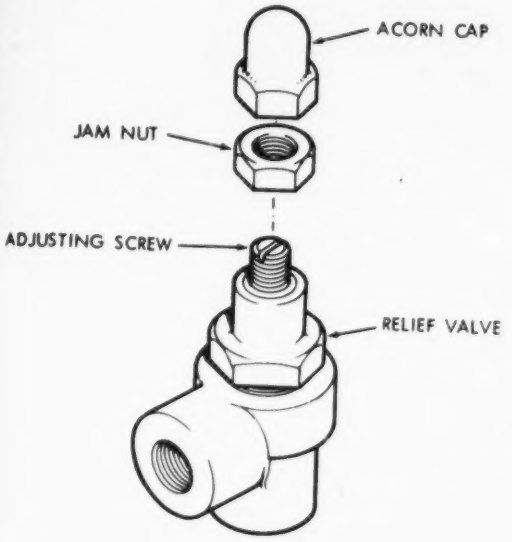
c. Disassembly. Refer to figures 4-50 and 4-51 to disassemble the relief valves.



ME 1905-217-34/4-50

1. Screw
2. Piston
3. Preformed packing
4. Bushing
5. Plunger
6. Nut
7. Knob
8. Plate
9. Screw
10. Adjusting screw
11. Retainer
12. Preformed packing
13. Spacer
14. Spring
15. Spring
16. Screw
17. Name plate
18. Body
19. Seat
20. Piston
21. Seal
22. Cover
23. Plug
24. Plug
25. Seat

Figure 4-50. Ramp system relief valve (hulls 8500-8519), disassembly and reassembly.



ME 1905-217-34/4-51

Figure 4-51. Ramp system relief valve (hulls 8520-8560 and 8580-8618), disassembly and reassembly.

d. Repair.

(1) Replace new packing and seal.

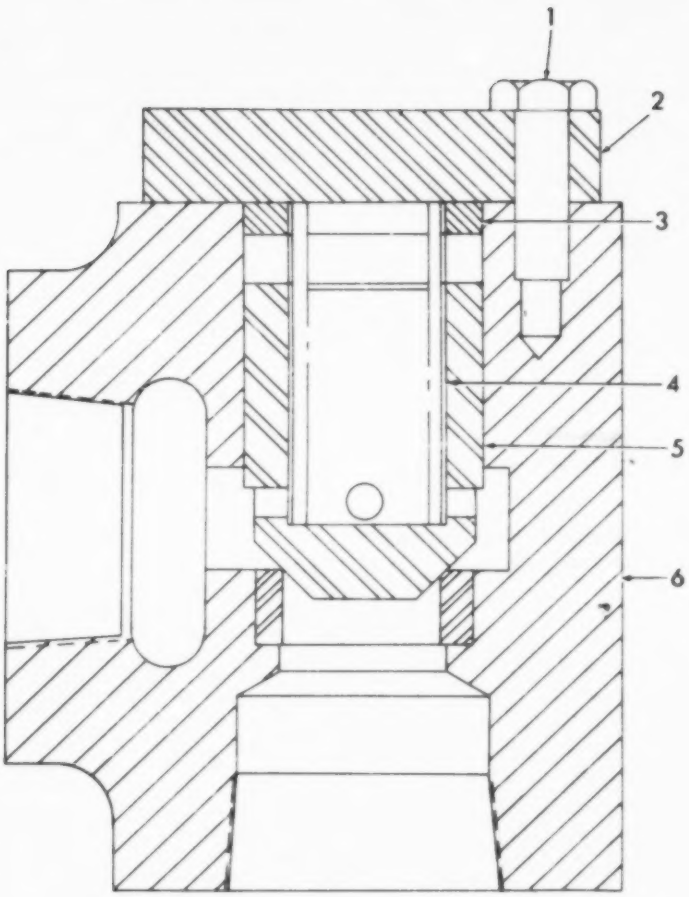
(2) Replace other defective parts as necessary.

e. Installation. Install the relief valve and adjust the pressure setting as prescribed in (TM 55-1905-217-12, para 4-93).

4-22. Ramp Hydraulic Check Valves

a. Removal. Remove the check valves (TM 55-1905-217-12, fig. 1-12 and 1-13).

b. Disassembly. Refer to figure 4-52 and disassemble the check valve.



1. Screw
2. Spool cap
3. Preformed packing
4. Spool spring
5. Oil control spool
6. Check valve body

TS 1905-217-34/4-52

Figure 4-52. Ramp hydraulic check valve, cross-section view.

c. Repair.

(1) Replace new packing.

(2) Replace a defective oil spool, (5, fig. 4-52)

(3) If other parts are damaged, replace valve.

d. Reassembly. Refer to figure 4-52 and reassemble the check valve.

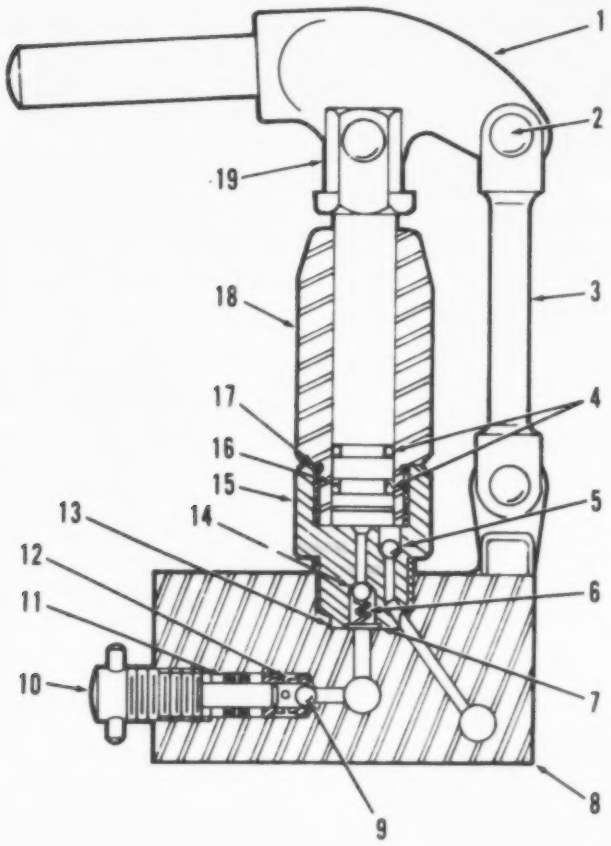
e. Installation. Install the check valves (TM 55-1905-217-12, fig. 1-12 and 1-13).

4-23. Ram Hoist Hand Pump (Hulls 8520-8560 and 8580-8618).

a. General. Refer to TM 55-1905-217-12, para 4-92 for description and servicing of the hand pump.

b. Removal. Remove the hand pump (TM 55-1905-217-12, para 4-92).

c. Disassembly. Refer to figure 4-53 and disassembly the hand pump.



ME 1905-217-34/4-53

1. Lever
2. Pump pin
3. Pump ring
4. Preformed packing
5. Check ball
6. Valve spring
7. Washer
8. Pump block
9. Release ball
10. Release screw
11. Washer
12. Release ball cage
13. Retaining ring
14. Pump valve ball
15. Pump valve block
16. Back-up ring
17. Preformed packing
18. Pump barrel
19. Pump piston

Figure 4-53. Ramp hoist hand pump, cross-section view (hulls 8520-8560 and 8580-8618).

d. Repair.

(1) Replace new packing and seal washer.

(2) Replace other defective parts as ecessary.

e. Reassembly. Refer to figure 4-53 and assemble the hand pump.

f. Installation. Install the hand pump (TM 55-905-217-12, para 4-92).

4-24. Ramp Locking Hydraulic Cylinders (Hulls 8540-8560 and 8580-8616).

a. General. Refer to TM 55-1905-217-12) for description of the ramp locking cylinders.

b. Removal. Remove the ramp locking cylinders (TM 55-1905-217-12, para 4-97).

c. Disassembly. Refer to figure 4-54 and disassemble the ramp locking cylinder.

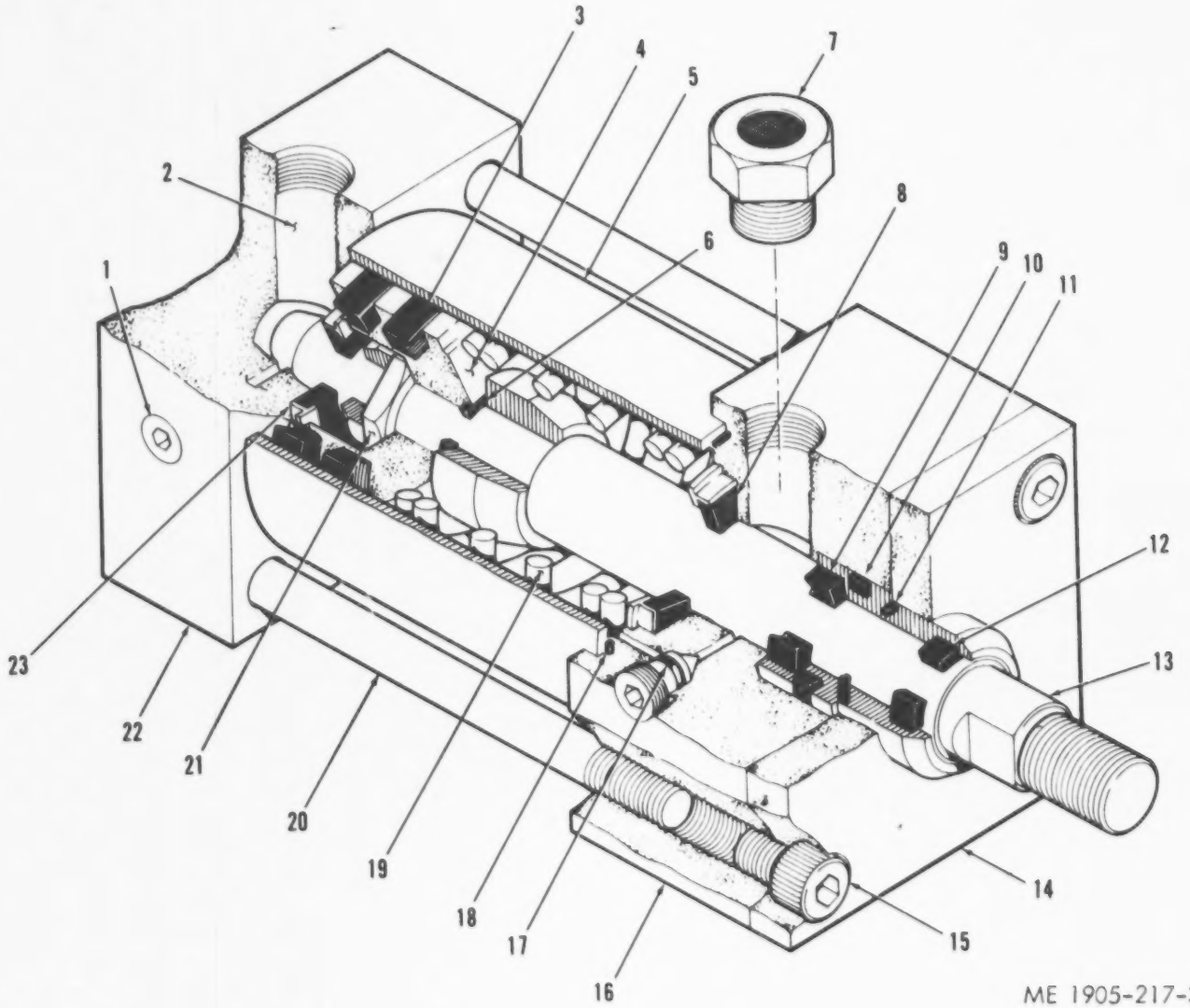


Figure 4-54. Ramp locking cylinder, cutaway view (hulls 8540-8560 and 8580-8618).

Key to figure 4-54.

1. Needle valve
2. Port
3. Piston cap
4. Piston
5. Barrel
6. Piston to rod seal
7. Breather plug
8. Cushion ring assembly
9. Rod seal
10. Rod gland OD seal
11. Rod gland
12. Rod wiper
13. Piston rod
14. Retainer plate
15. Retainer bolt
16. Head
17. Needle valve seal
18. Barrel seal
19. Return spring
20. Tie bolt
21. Piston nut
22. Cap
23. Cushion ring assembly

(1) Remove the four retainer plate bolts (15, fig. 4-54) and retainer plate (14).

(2) Remove the rod gland (11) and seals (10).

(3) Remove tie bolt nuts (21) and end cap (22).

(4) Remove barrel (5) from head (16) with piston (4) and piston rod inside.

(5) Pull piston rod (13) assembly from barrel.

NOTE

Do not remove piston from piston rod unless parts are damaged or definite leakage has occurred past the piston. If piston is removed from the piston rod, the piston nut must be torqued to 55 ft. lbs. on reassembly.

d. Cleaning, Inspection, and Repair.

(1) Wash all parts thoroughly in solvent, FED. SPEC. PD-680) type I, and place them on a clean surface for inspection.

(2) Discard old seals, wiper, piston cups and glands.

(3) Check cylinder, piston and piston rod for scores and burrs. Carefully remove burrs by light stoning or lapping. If scoring appears to be excessive, replace the defective parts.

e. Reassembly.

(1) Lubricate replacement parts before assembly with clean hydraulic fluid.

(2) Place piston in groove nearest the rod end with cupped side facing the rod end. Enter the piston and rod assembly into the barrel until the empty groove is exposed on the opposite end. Place the cup in the exposed groove with cupped side facing away from the rod end. Pull the rod and the piston into the barrel.

(3) Reassemble the barrel (5) to the head (16).

(4) Replace tie bolt nuts (21).

(5) Replace cap (22).

(6) Torque tie rods to 15 ft lbs each; tightened a little at a time, alternately with opposite tie rods until correct torque is reached.

f. Gland and Seal Replacement. Rod gland, rod seal, rod wiper and gland OD seal shall be replaced as follows:

(1) Extend piston rod 1/4 of stroke.

(2) Remove pressure from system.

(3) Support rod and cylinder to prevent damage when rod gland is removed.

(4) Remove rod and accessories.

(5) Remove burrs from rod lats.

(6) Remove retainer bolts (15).

(7) Remove retainer plate (14).

(8) Remove rod gland (11) by prying with screwdriver in pryout groove.

(9) Clean all parts.

(10) Lubricate parts to be replaced with hydraulic fluid.

(11) Push or tap rod gland (11) back into head being careful not to damage rod seals (9, 10).

(12) Replace retainer plate (14) and retainer bolts (15).

(13) Torque retainer bolts to 15 ft lbs.

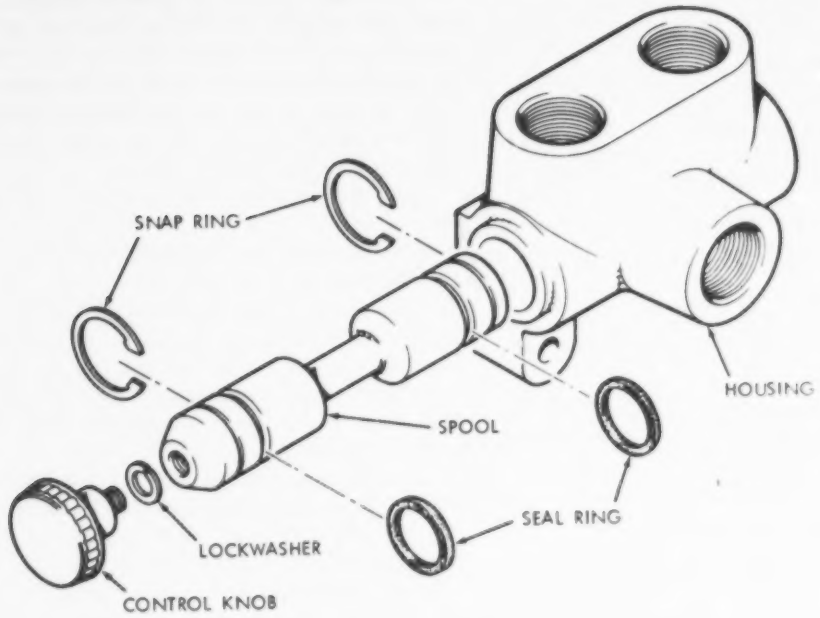
g. Installation Install the ramp locking cylinders (TM 55-1905-217-12, para 4-97).

4-25. Ramp Locking System Two-Way Selector Valve (Hulls 8540-8560 and 8580-8618).

a. General. Refer to TM 55-1905-217-12, para 4-98, for a description and location of the selector valve.

b. Removal. Remove the two-way selector valve (TM 55-1905-217-12, para 4-98).

c. Disassembly. Refer to figure 4-55.



ME 1905-217-34/4-55

Figure 4-55. Ramp locking system two-way selector valve, exploded view (hulls 8540-8560 and 8580-8618).

(1) Remove snap rings at knob end and rear end of spool.

(2) Push knob in until rear seal is exposed, remove the rear seal.

(3) Spool may be now removed from the valve housing. Front seal from spool.

d. Cleaning, Inspection, and Repair.

(1) Discard oil seals. Wash parts in solvent, (FED. SPEC. PD-680), type I, and place them on a clean surface for inspection.

(2) Inspect the valve spools and housing bore for burrs and scoring.

(3) Carefully remove burrs by light stoning or lapping.

(4) If scoring appears to be excessive, replace the spool and housing.

e. Reassembly.

(1) To prevent cutting seal on sharp edges, wrap spool in three or four layers of glossy paper leaving only the front seal groove exposed. Instal new seal from rear end of spool over the paper and into the front seal groove.

(2) Apply clean hydraulic fluid to a new seal. Remove paper and insert spool in body and with a rotating action on knob, push the spool in until the front seal disappears and until the rear seal groove is exposed.

(3) Install rear seal in groove.

(4) Apply clean hydraulic fluid to rear seal.

(5) Install rear snap ring and with firm rotating action pull spool to stop.

(6) Install front snap ring.

f. Installation. Install the two-way selector valve (TM 55-1905-217-12, para 4-98).

CHAPTER 5

REPAIR OF PROPELLER, SHAFT, RAMP, AND HATCHES

Section I. PROPELLER AND SHAFT ASSEMBLY

5-1. Propeller

a. Removal. Remove the propeller (TM 55-1905-217-12).

b. Inspection. Inspect for damaged or bent blades.

c. Repair. The tools necessary for small craft propeller repair are a blacksmith's forge, an anvil, files, and an oxacetylene torch. Straightening and finish work can be conveniently and economically executed in the field.

(1) *Importance of Propeller Straightening.* Straightening and balancing minimizes outboard bearing maintenance and avoids over-loading engines, loss of efficiency and speed, and poor performance of misshaped propeller.

(2) *Heating Propellers.* Small bends or depressions in bronze propellers can be straightened while the propeller is cold. Because cold working hardens bronze, larged bends or irregularities must be repaired using heat to prevent cold cracks from occurring. When heat is used, heat propeller to a dull red color in a forge or with a gas flame. For overall heating where large surfaces are involved, the forge is faster and gives a more uniform application of heat. Figure 5-1 shows a propeller being heated with a forge. For small or localized repairs, a gas flame should be used.

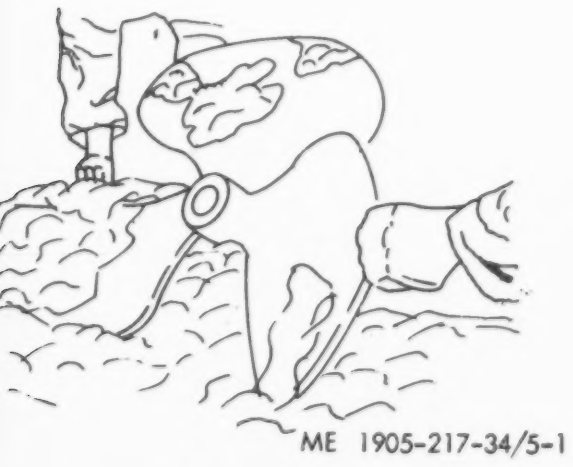
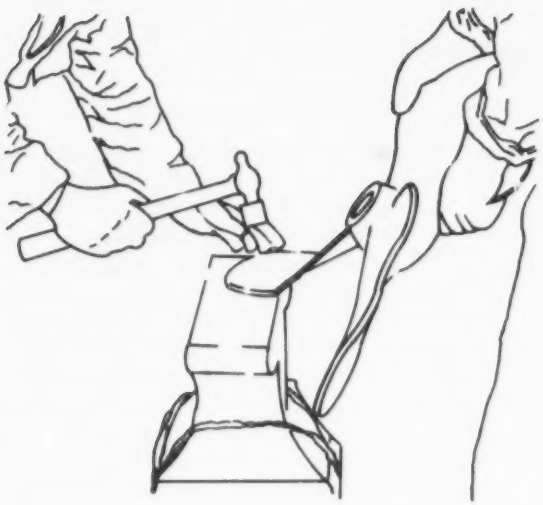


Figure 5-1. Heating propeller with a forge.

CAUTION

Bronze becomes weak at high temperatures and the propeller, if struck, can sag or break. Exercise care when handling or repairing a heated propeller.

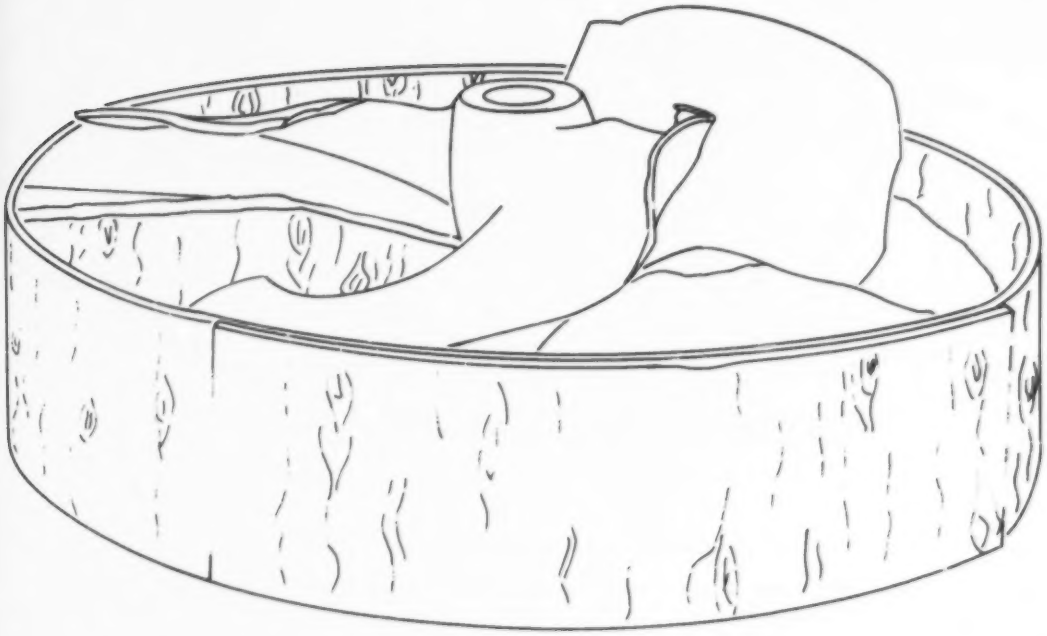
(3) *Straightening the Blade.* On small propellers, tightly rolled bends are unrolled with blacksmith's tongs. Other irregularities are peened. It is advantageous to peen a bend on its concave or hollow side. On small propellers, strike the blade with a light hammer while backing the peening with the blade on an anvil. A typical peening operation is shown in figure 5-2. Large propellers are peened by using air hammers with a round edge calking tool. The metal unrolls like wet leather under the hammer when the blade is at the correct temperature. Work should be stopped and the propeller reheated when the sound of the metal under the hammer changes from a dull, flat sound to a sharper, ringing sound. Several propellers can be heated and straightened at the same time. Most blades can be reshaped with two or three heatings. This can be done alternately so that the blade of one propeller is cooling while another is being heated and worked. In this way, the annealing is continuous, and no water cooling is necessary because a separate annealing step is not used. During straightening operations, the propeller should be compared occasionally to a propeller pitch block.



ME 1905-217-34/5-2

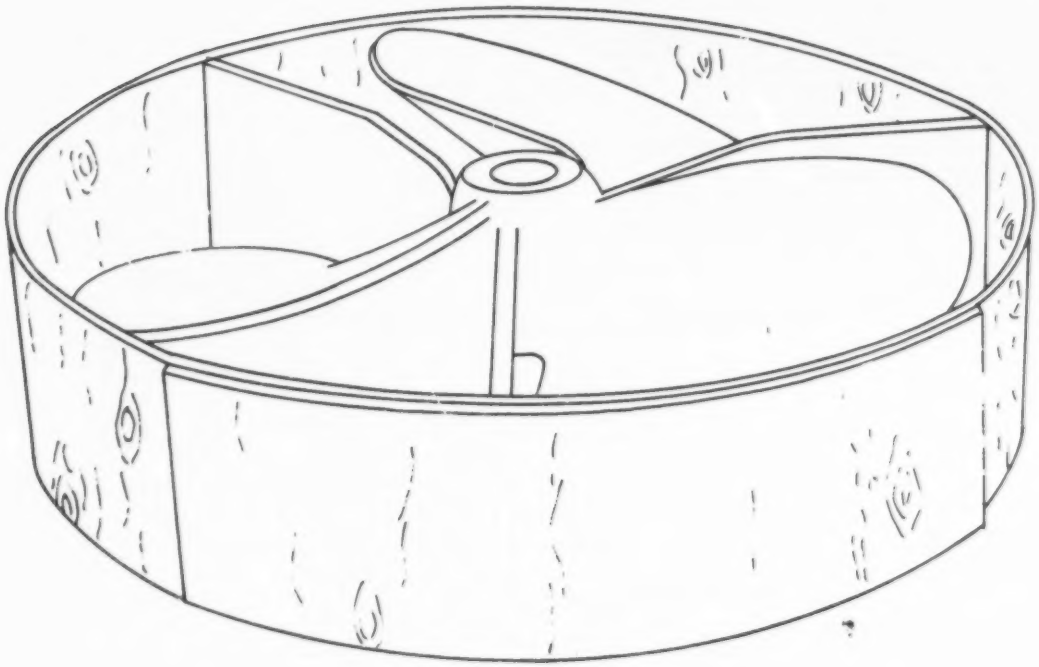
Figure 5-2. Peening propeller on anvil.

(4) *Making and Using Pitch Block.* A pitch block can be made by pouring concrete in a plywood box and shaping the upper surface of the concrete to fit a new propeller. Figure 5-3 shows a badly damaged propeller on a block before straightening. Figure 5-4 shows the propeller on the pitch block after straightening. In figure 5-4 the upper edges of the blade are about an inch above the pitch block. This is because the pitch block is for a propeller with a pitch of 17 inches whereas the propeller is a 24-inch diameter propeller with a pitch of 18 inches. An efficient blacksmith with an eye for blade configuration can determine the amount of shaping and pitch alinement.



ME 1905-217-34/5-3

Figure 5-3. Badly damaged propeller on pitch block.



ME 1905-217-34/5-4

Figure 5-4. Propeller on pitch block after straightening.

(5) *Damaged, Notched Edges.* The edges of the straightened propeller shown in figure 5-4 have notches. Normally notches of the size shown in figure 5-4 are not filled if other vessels are deadlined for repair. Damaged edge repair is covered in paragraph (8) (b), below.

(6) *Repairs by Welding.* The location of the repair governs the kind of weld used and the care necessary. Root sections of the blade carry more stress than sections near the tip and therefore are critical. All metal deposits above the surface of the blade will have to be removed.

(7) *Repair of Root Sections.* Because of the high stresses on the blade between the hub and 0.4 radius, any repair in this area is considered major repair, and a welding procedure that can be depended upon to produce a strong, sound weld substantially free of residual stresses should be used. Metallic arc welding, multiplelayer gas welding, and the hot-flow process are approved methods for root section repair.

(8) *Repair of Sections Outside the 0.4 Radius.* Repairs in these areas are relatively minor and can be accomplished with the use of multiple-layer gas welding or metallic arc welding.

NOTE

The use of silver brazing alloy or any other low temperature brazing alloy is not an approved method, as these alloys have insufficient hardness to resist the erosive action of high velocity water.

(a) *Repair of cavitation pits.* Cavitation pits can be weld-filled, using any approved method.

(b) *Repair of blade edges.* Broken propeller edges can be replaced by welding a corresponding edge from a dis-propeller (fig. 5-5). Cracks are ground or cut open and then welded together. The entire crack must be ground out or it will start cracking again. If necessary, blades can be built up with the same welding rods used in the process of welding. Small notches in the edges are sometimes filled by welding.

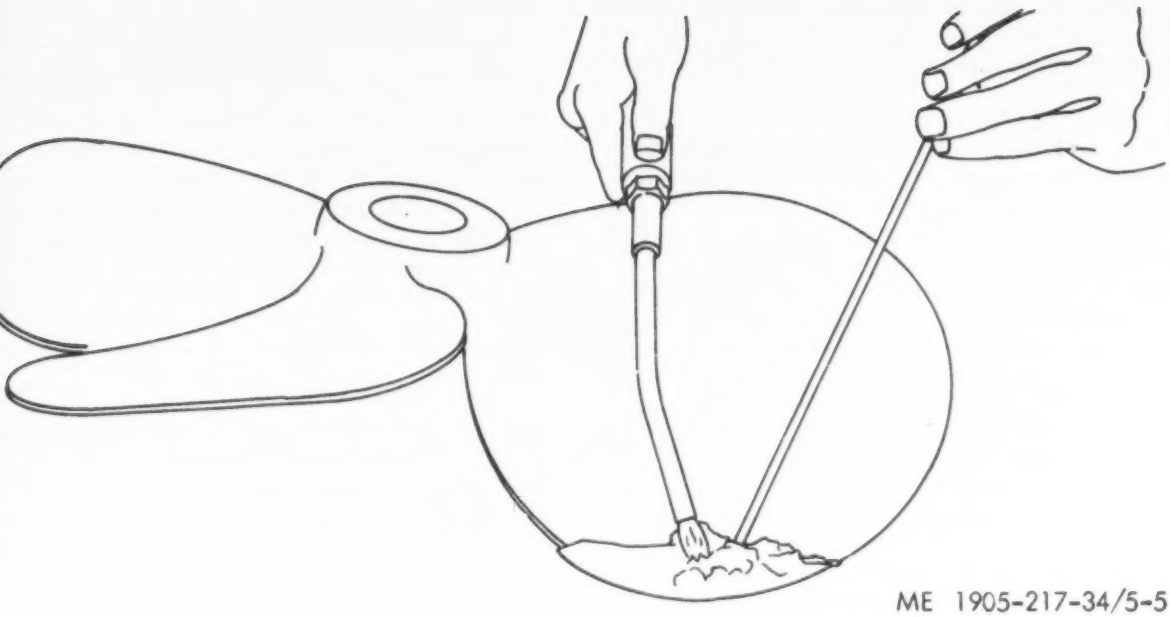


Figure 5-5. Welding a replacement section to a propeller.

(9) *Finishing Welded Areas.* Beads should be round or filed smooth to match original surface ontours. Splatter and flux should be removed by craping, chipping, and/or grinding or filing. Welded areas should be annealed if required.

(10) *Metallic Arc Welding.* For major or inor repair to manganese-bronze propellers, a overed aluminum-bronze electrode composed of 0 percent copper and 10 percent aluminum hould be used. Phosphorous bronze rods should nly be used for minor repairs, as these rods have nly about one half the strength of the base etal. Each edge of the repair sections should be eveled 45 degrees (included angle 90 degrees) nd the root of the bevel should be rounded to a inimum ¼-inch radius; however, if the depth is ver 1 inch, the sides can be beveled at 15 degrees fter the width of the groove at the top exceeds ½ inches. The section to be repaired should be hipped to sound metal and positioned for ownhand welding. Welds can be made in the ertical position; however, suitable copper or arbon dams should be used to aid in supporting he weld metal. In order to obtain a proper joint, is imperative that the base metal be locally reheated. The preheat temperature should be etween 600° F. (316° C. and 427° C.). In an mergency, a temperature of 400° F. (204° C.) an be used. An approved rod of ¼-, 5/16-, or /8-inch diameter should be used, especially on ropeller sections over 3/8 inch thick. Smaller iameters, 5/32 inch and 3/16 inch, should not be used unless absolutely necessary, and then only when considerable preheating has been done. With sufficient preheat, lower values of the current ranges recommended by the electrode manufacturer can be used. Although lower currents are desirable, the operator's skill and experience must be considered. Therefore, higher currents are preferable to currents too low. Higher currents risk fine porosity in the weld metal, but currents too low risk poor fusion and slag inclusions.

(11) *Hot-Flow Process.* The hot-flow process provides a satisfactory method for major repairs. This process consists of flowing molten metal of approximately the same chemical composition as the base metal into the joint. This flow washes away and replaces the parent metal and forms a continuous member upon solidification. Foundry and mold equipment is necessary for the use of this process.

(12) *Multiple-Layer Gas Welding.* The multiple-layer gas welding method is an approved major and minor repairs of propellers. The edges to be welded are beveled to form a 75-degree, single V-groove weld for thicknesses less than 1½ inches. A 75-degree double V-groove is used if the thickness of the section is greater than 1½ inches. A copper-zinc, lowfuming, welding rod of the proper size and in accordance with Military Specification MIL-R-19631 is used with a suitable brazing flux for repair of manganese-bronze propellers. A carefully adjusted oxidizing flame is

essential for sound welds. A forehand method of welding should be used and the weld metal deposited in beads with limited oscillation not exceeding 1½ times the diameter of the welding rod.

(13) *Welding-Preheat and Stress Relief.* Because copper-zinc alloys are susceptible to stress-corrosion or season cracking, stress must be relieved, as the propeller can crack after being returned to service. The use of local preheat above 400 ° F. (204 ° C.), preferably between 600 ° F. and 800 ° F. (316 ° C. and 427 ° C.), will preclude the accumulation of harmful stresses. Hot-flow welds and large gas welds are automatically preheated and slowly cooled, and stress relief can be safely omitted after welding. Arc welds and small gas welds should be preheated with a torch or other suitable means and then cooled slowly. If it is considered more desirable to stress relief after welding, the following procedure is recommended. Heat slowly to 750 ° F. (399 ° C.) and hold at this temperature for at least 1 hour per inch of thickness of metal in the welded area; cool slowly, approximately 2 ° F., per minute, until metal is below 250 ° F. (121 ° C.), after which air-cooling is permissable. During all preheating, welding, or stress relieving, the propeller should be well supported in order to avoid sagging and distortion. Repairs, particularly to heavier sections of the propeller, should be performed with care in order to avoid thermal cracks or tears due to shrinkage stresses which can be imposed on the base metal.

d. Installation. Install the propeller (TM 55-1905-217-12, para 3-20).

5-2. Propeller Shaft Assembly

a. Removal. Remove the propeller shaft assembly (TM 55-1905-217-12, para 3-21).

b. Repair.

(1) *Pitted Shafting.* Cases of severe pitting in outboard shafting, resulting from damaged or porous covering, should be reported to the appropriate authority who will decide whether the shaft is suitable for future service. If the pitted shafting is approved for reconditioning, the sharp edges of the pits should be well rounded by grinding and the corroded areas should be dressed down to the solid metal surface. Ground out pits and corroded areas, if extensive and of shallow depth, should be filled with approved cavity build-up material. Pits and corroded areas beyond allowable depths should be built-up by welding and covered with a protective rubber or plastic material.

(2) *Vibration.* If objectionable vibrations exist, the shafting sections should be removed and checked for straightness. Dial indicator runouts of shafting ends, measured at the propeller or coupling tapers, should total less than 0.003 inch (0.0015-inch eccentricity), which should prevent excitation of the first-order vibrations (one vibration per shaft revolution). Runouts in excess of 0.003 inch total, giving an unacceptable performance, must be rectified or replaced by a new shaft section.

(3) *Bent Shafting.* Approval by the appropriate authority should be obtained prior to straightening severely bent shafting. Repair to the shafting section can be done by the spot heating method, or electric induction heating, after which the shaft is straightened by mechanically controlled forces.

(4) *Cracks in Shafting.* Cracks found in propulsion shafting should be thoroughly probed to determine the depth and length of the cracks. If shafting is determined to be repairable, weld crack by an approved method.

(5) *Eccentricity.* The dial indicator runout for any length of shafting, with respect to the axis of rotation and exclusive of journals and ends, should be limited to an eccentricity of approximately 0.003 inch. If, when the shafting is rotated 360 degrees, runouts greater than this figure are found, this eccentricity should be reduced to the lowest possible limit. A record should be kept of all installed shafting where eccentricities exceed 0.003 inch. Shafting should be replaced if objectionable vibration is still present.

(6) *Electrolytic Action.* Zinc protector collars on the shafting should be replaced as necessary. Steel shafting that is exposed to sea water should be protected from electrolyte action by a rubber or plastic protective covering when electrolytic action occurs between the steel shaft and the bronze bearing journal sleeve.

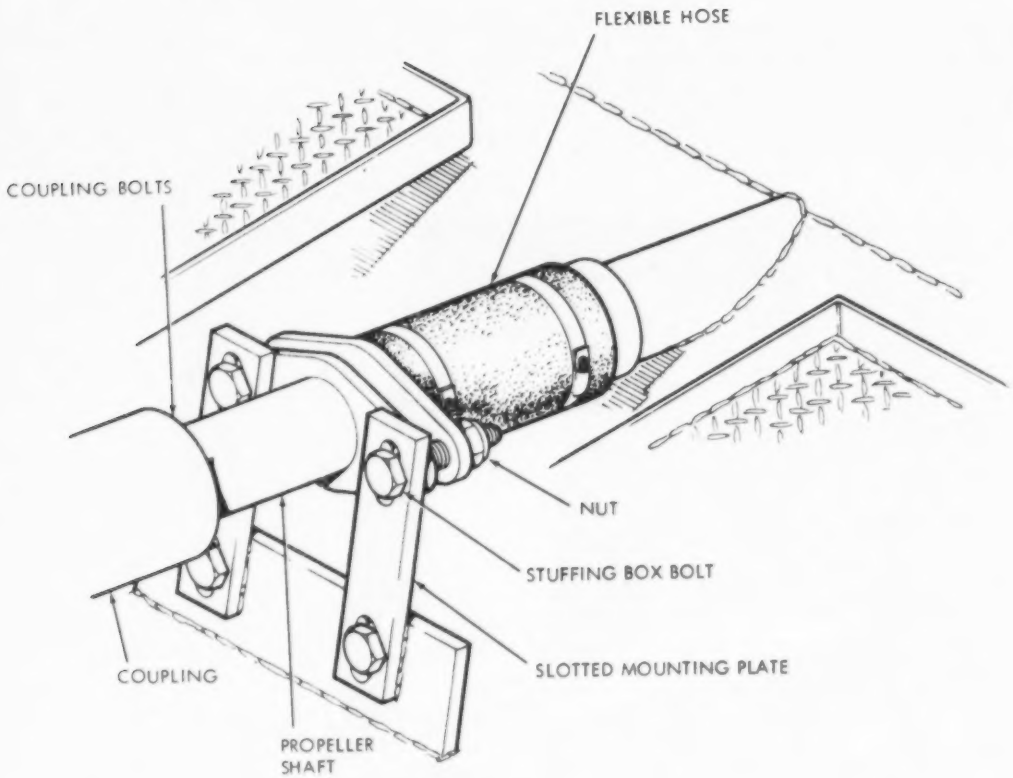
(7) *Plugging Shaft Ends.* All shafting that is exposed to sea water and has been bored throughout its entire length must have both ends plugged to prevent water from seeping into the hollow shaft and into the vessel. One method is by tapping the shaft bore with a tapered pipe thread. In this method, a threaded plug is fitted and installed with thread compound to insure the watertightness of the plug.

c. Alinement. Aline the propeller shaft. (TM 55-1905-217-12).

d. Installation. Install the propeller shaft (TM 55-1905-217-12, para 3-21).

5-3. Stuffing Box

a. Removal. Remove the nuts (fig. 5-6) bolts, and mounting plates and remove the stuffing box from the shaft.



ME 1905-217-34/5-6

Figure 5-6. Stuffing box, removal and installation (hulls 8540-8560 and 8580-8618).

b. Inspection. Inspect the stuffing box (TM 55-905-217-12, para 3-19).

c. Installation. Install the plates, nuts, and bolts and secure the stuffing box (fig. 5-6).

-4. Anodes

a. General. Anodes should be replaced when they become wasted away to the point that they fail to provide adequate mass and surface area. They should also be replaced or reattached if loose. Anodes for installation and replacement will conform to types ZHS or ZSS of Military Specification MIL-A-18001. Type ZHS will be used for large vessels and type ZSS will be used for small vessels. Type ZHS measures 1¼ by 6 by 12 inches, weighs approximately 23.5 pounds, and has cast-in steel straps with protruding ends for attachment. Type ZSS measures 1¼ by 3 by 12 inches, weighs approximately 11.8 pounds, and has cast-in steel straps with protruding ends for attachment. Anodes will be located in the immediate vicinity of the propellers and will be symmetrically distributed. The distance between any two anodes will not be less than 2 feet.

b. Removal. Remove the mounting nuts from the anode straps and remove the anodes as shown in figure 5-7.

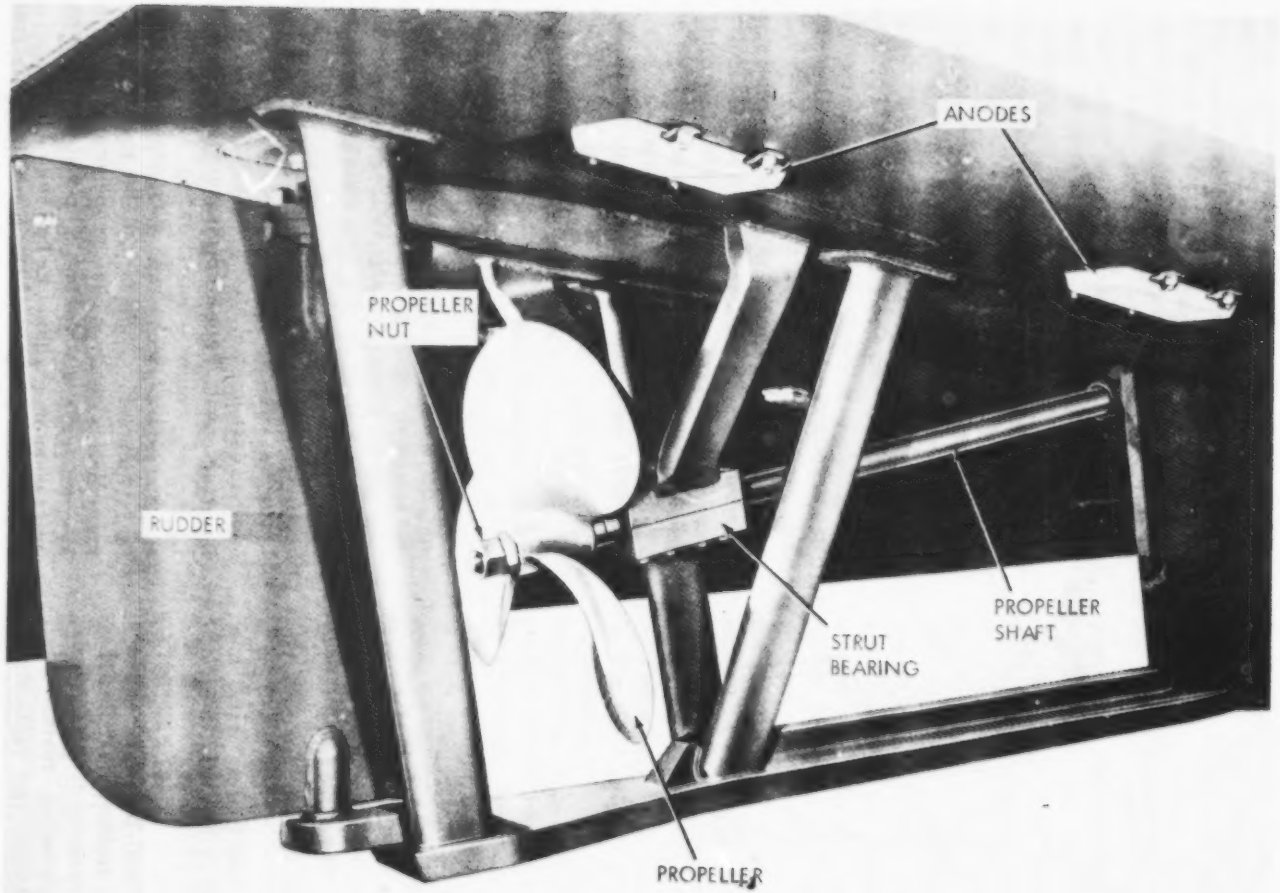


Figure 5-7. Anodes, removal and installation.

c. Installation. Install the anodes as shown in figure 5-7.

5-5. Rudder and Gudgeon Bearing

a. Inspection. Inspect the rudder and bearing for visible damage such as bends, cracks, and breaks.

b. Removal. (Fig. 5-8).

(1) Remove four bolts from rudder shoe casting.

(2) Remove four bolts from upper and lower stock. Allow rudder to drop approximately $\frac{1}{4}$ inch to separate the stocks.

(3) Slide the rudder assembly aft to clear the skeg bar.

c. Disassembly. Remove rudder shoe casting and gudgeon bearing assembly. Replace assembly if gudgeon bearing is worn. Grease the bearing.

d. Reassembly. Install shoe casting and rudder in reverse order of disassembly.

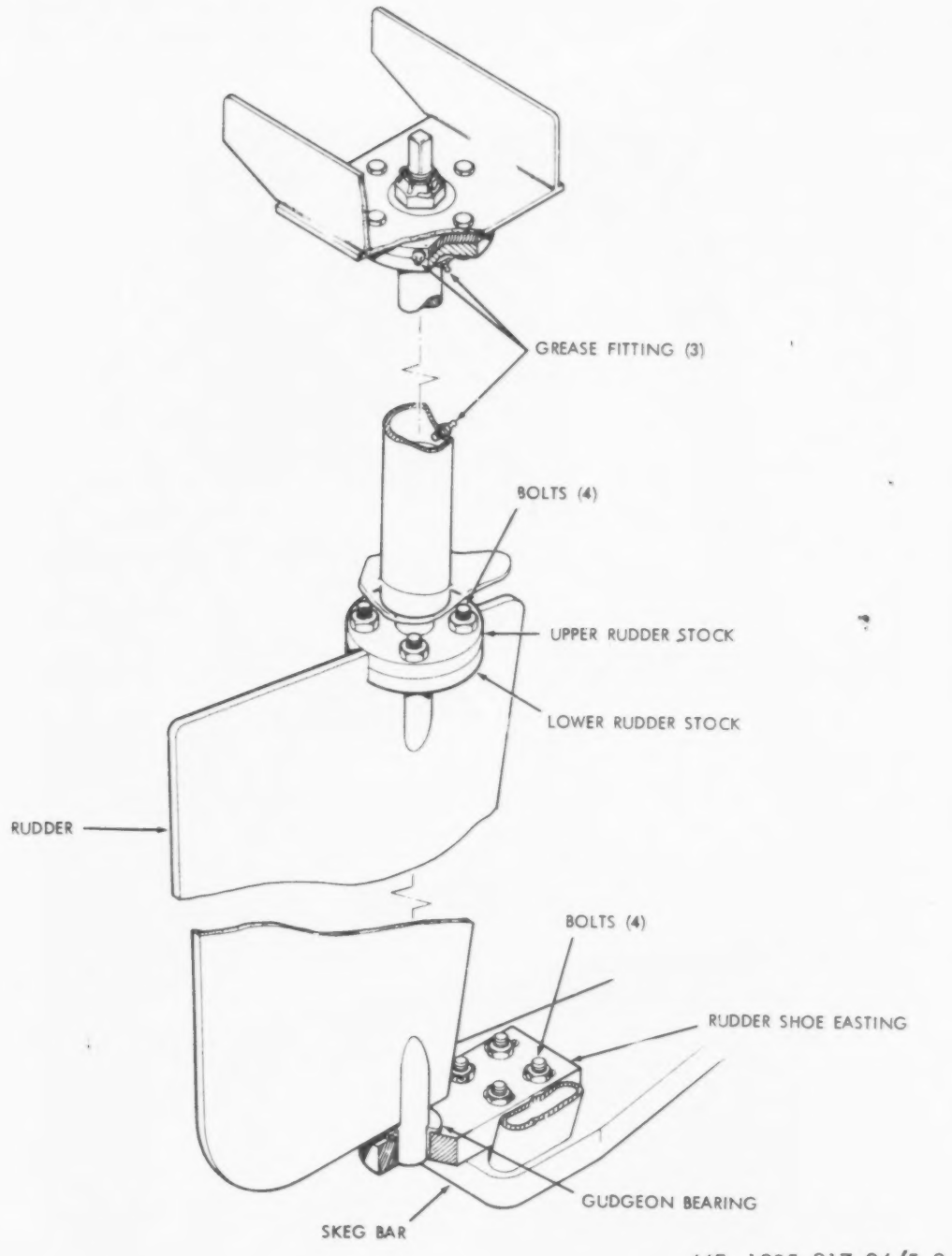


Figure 5-8. Rudder and bearing, removal and installation.

e. Installation. Install the rudder and gudgeon bearing in reverse order or removal (*g.* Above). Apply grease to grease fittings.

Section II. HATCHES AND RAMP ASSEMBLY

5-6. Deck Hatches

a. Removal. Remove the hatches as described in para. 2-7. Refer to TM 55-503, Chapter 2, Section II.

b. Repair.

(1) Straighten bends and dents.

(2) Weld minor cracks and breaks.

(3) Replace defective or missing hardware.

(4) Replace gaskets that show the slightest signs of defect or deterioration.

(5) Replace a hatch that is damaged beyond repair.

c. Installation. Install hatches in reverse of removal (para 2-7).

5-7. Ramp Assembly

a. Removal.

(1) Use a lifting hoist to support the ramp and raise the front end of the LCM 8.

(2) Cut the ramp cables to free them from the ramp.

(3) Open the ramp far enough to permit access to the hinges and pins.

(4) Drive the hinge pins out of the hinges and carefully remove the ramp from the vessel.

b. Cleaning, Inspection, and Repair.

(1) Clean all parts of the ramp with solvent, FED. SPEC. PD-680, and dry thoroughly. Remove scale, rust and loose paint.

(2) Inspect for bent or broken hinges. Check for cracks, excessive wear and other damage.

(3) Weld minor cracks, straighten dents, and replace defective hinge pins. Inspect cables for fraying.

c. Installation.

(1) Position the ramp on the front of the LCM so that the hinges are in line to permit installation of the hinge pins.

(2) Drive in the pins to secure the ramp to the vessel.

(3) String new cables along the pulleys and install ends on ramp.

CHAPTER 6

REPAIR OF COMMUNICATION AND NAVIGATION EQUIPMENT

Section I. COMMUNICATION EQUIPMENT

6-1. Radio Set AN/SRC-32 (Hulls 8540-8560 and 8580-8619)

NOTE

This Section contains instructions for radio sets that have either been installed or authorized for use on the LCM 8. Refer to the appropriate TM's cited in this section as well as Appendix A.

a. Removal. Refer to Figure 6-1 and proceed as follows:

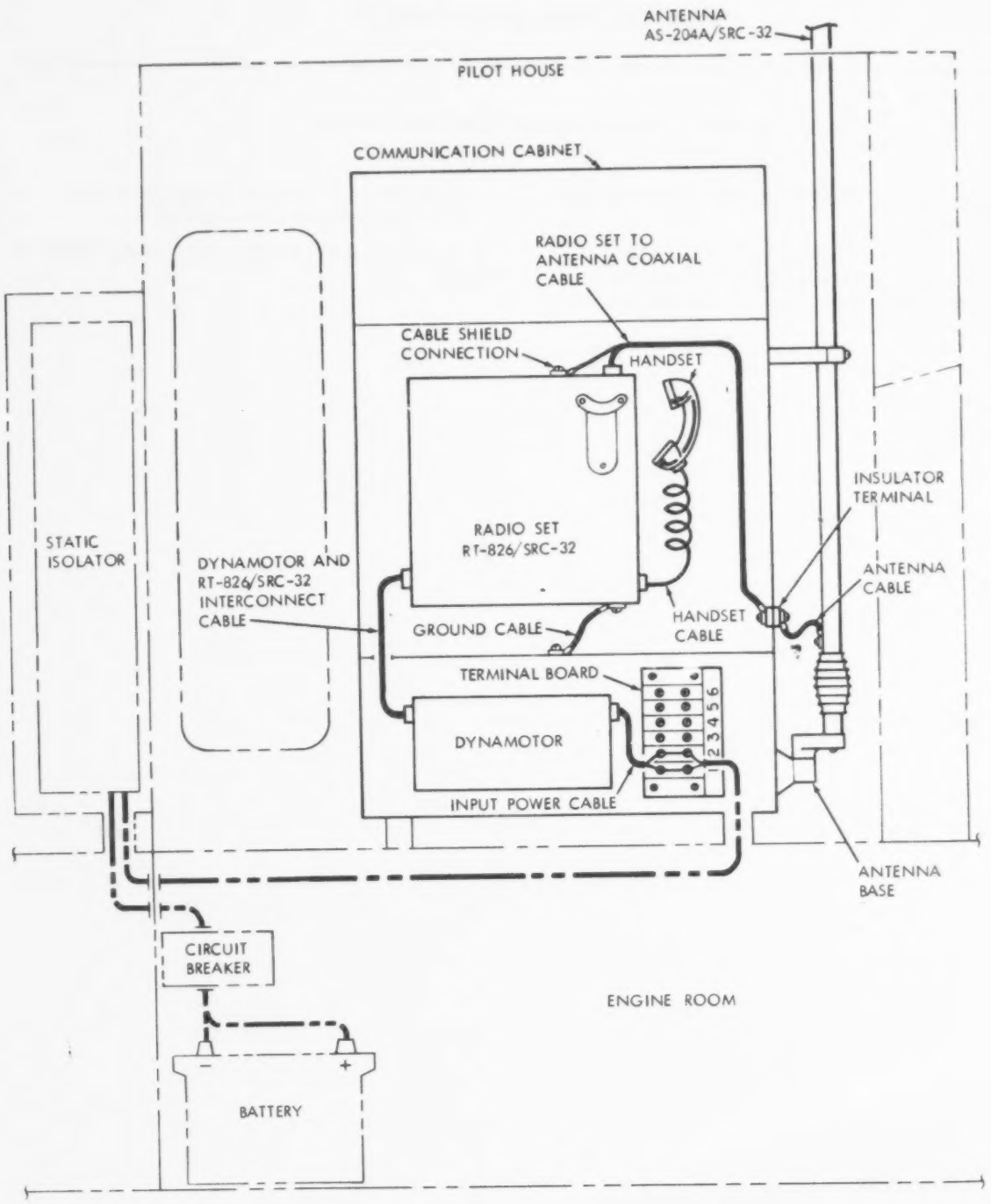


Figure 6-1. Radio set NA/SRC-32 (hulls 8540-8560 and 8580-8618).

CAUTION

Disconnect ground cable of battery prior to removal of components.

(1) Remove communications cabinet front panel by unfastening thumb screws. Retain panel.

(2) Disconnect handset cable from receiver/transmitter RT-826/SRC-32. Remove and retain handset H-272/SRC-32.

(3) Remove the covers from receiver/transmitter and dynamotor. Retain covers.

(4) Disconnect the input power cable at terminal block (TB-1) in the dynamotor and at the terminal block in the communications cabinet. Remove and retain cable.

NOTE

When removing cables from terminal blocks record the position of wires on terminal block studs to assure correct reinstallation of cables.

(5) Disconnect ground cable and cable shield from ground studs in receiver/transmitter. Remove mounting bolt, washers and nut attaching ground cable to case. Remove and retain cable and attaching hardware.

(6) Remove cable between dynamotor and receiver/transmitter. Disconnect cable at terminal block (TB-2) in dynamotor and terminal block (TB-1) in receiver/transmitter. Retain cable.

(7) Disconnect the cable between receiver/transmitter and insulator terminal. Remove and retain cable.

(8) Disconnect the antenna cable between antenna and insulator terminal. Remove and retain cable.

(9) Remove the antenna assembly from antenna base by unlatching the holding latch. Retain the antenna assembly.

(10) Remove the receiver/transmitter by removing the remaining mounting bolts, washers, and nuts. Retain the mounting hardware.

(11) Remove the dynamotor from base of the communications cabinet by unfastening straps securing dynamotor.

(12) Install covers removed from the receiver/transmitter and dynamotor in step (3).

(13) Close and latch communications cabinet front panel. Connect the battery ground cable.

b. Repair. Refer to TM 11-5820-689-15.

c. Installation Figure 6-1. Install components in reverse order of removal. Be certain that proper polarity is observed in connecting input cable.

6-2. Radio Set AN/VRC-46 (Hulls 8540-8560 and 8580-8619)

a. Removal. Refer to figure 6-2 and proceed as follows:

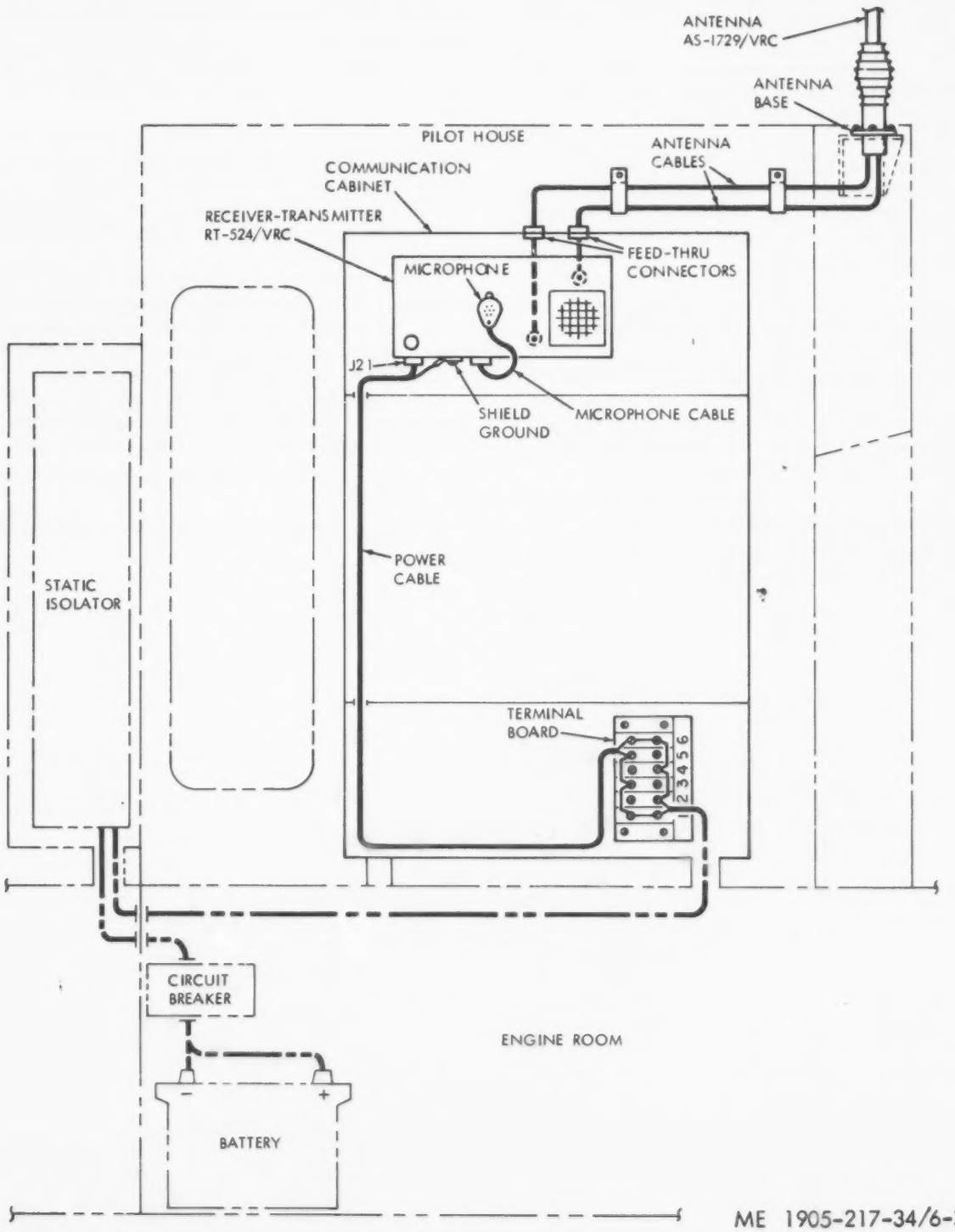


Figure 6-2. Radio set AN/VRC-46 (hulls 8540-8560 and 8580-8618).

CAUTION

Disconnect ground cable of battery assembly prior to removal of components.

(1) Remove communications cabinet front panel by unfastening thumb-screws. Retain panel.

(2) Disconnect the two cables at antenna base. Tape cable ends; coil and stow cables at bulkhead clamp loop.

(3) Disconnect the two antenna cables at receiver/transmitter, loosen feed-through connectors at top of cabinet. Tape cable ends; coil and stow cables in clamp loop.

NOTE

Record position of cable wires on studs or connectors to assure correct reinstallation of cables.

(4) Remove antenna and base from the support bracket by removing the four screws, nuts and washers. Retain attaching hardware.

(5) Disconnect microphone cable at the connector. Remove and retain microphone.

(6) Disconnect power cable and shield ground at connector J21. Tape and stow cable at bulkhead.

(7) Disconnect power cable at the terminal block in base of cabinet. Tape and stow cable at bulkhead.

(8) Remove receiver/transmitter AN/VRC-46 from its mounting.

(9) Replace front panel on communications cabinet. Connect battery ground cable.

b. Repair. Refer to TM 11-5820-401-10.

c. Installation Figure 6-2. Install components in reverse order of removal. Be certain that proper polarity is observed in connecting input cable.

6-3. Radio Set. AN/VRC-47 (Hulls 8540-8560 and 8580-8619)

a. Removal. Refer to figure 6-3 and proceed as follows:

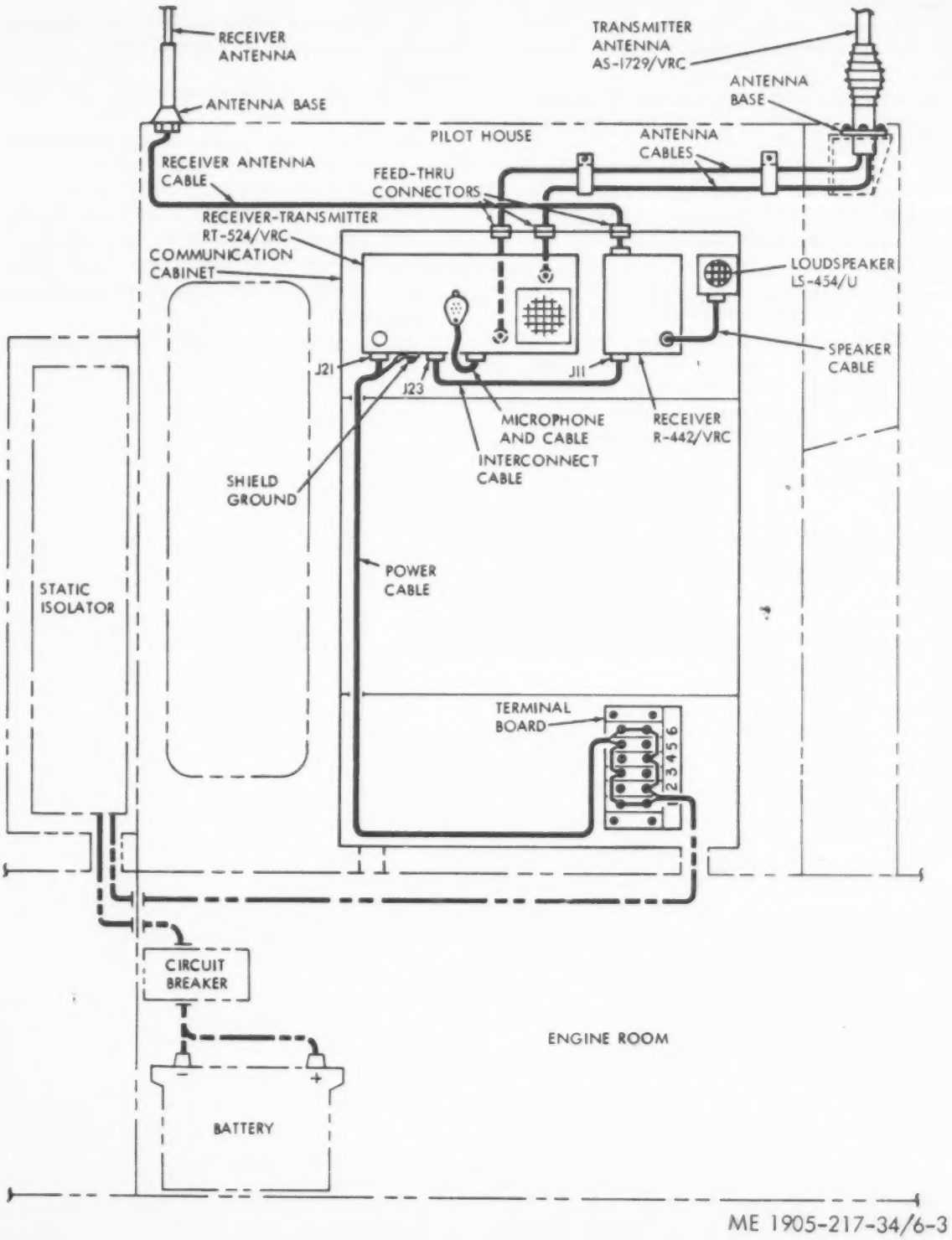


Figure 6-3. Radio set. AN/VRC-47 (hills 8540-8560 and 8580-8618).

CAUTION

Disconnect ground cable of battery assembly prior to removal of components.

(1) Remove communications cabinet front anel by unfastening thumbscrews. Retain panel.

(2) Disconnect speaker cable at the audio onnector on receiver R-442/VRC and remove the peaker.

(3) Disconnect the transmitter antenna's to ables at antenna base. Tape cable ends and oil nd stow cables at bulkhead clamp loop.

NOTE

Record position of cable wires on studs or connectors to assure correct reinstallation of cables.

(4) Disconnect the two transmitter antenna ables at receiver transmitter, loosen feed-hrough connectors at top of cabinet. Tape cable nds and stow cables at clamp loop.

(5) Disconnect receiver antenna cable at base f antenna.

(6) Disconnect receiver antenna cable at eceiver. Loosen feed-through connector and emove and retain cable.

(7) Remove microphone cable from connector n the receiver-transmitter RT-524/VRC.

(8) Remove interconnect cable between eceiver-transmitter and the receiver. Disconnect able at a connector J11 on receiver and connector J23 on receiver-transmitter. Remove and retain cable.

(9) Disconnect power cable and shield ground at connector J21 on transmitter. Tape and stow cable at bulkhead.

(10) Remove transmitter antenna and antenna top section from support bracket. Retain antenna and top section.

(11) Remove receiver antenna and base from support bracket by removing screws, nuts and washers. Retain antenna, base and attaching hardware.

(12) Disconnect power cable from terminal board at base of communications cabinet. Tape and stow cables at bulkhead.

(13) Remove the receiver-transmitter units from their respective mountings.

(14) Reinstall the communications cabinet from panel. Connect battery ground cable.

b. Repair. Refer to TM 11-5820-401-10.

c. Installation. Install components in reverse order of removal. Be certain that proper polarity is observed in connecting input cable.

6-4. Radio Set AN/GRC-106 (Hulls 8540-8560 and 8580-8618)

a. Removal. Refer to figure 6-4 and proceed as follows:

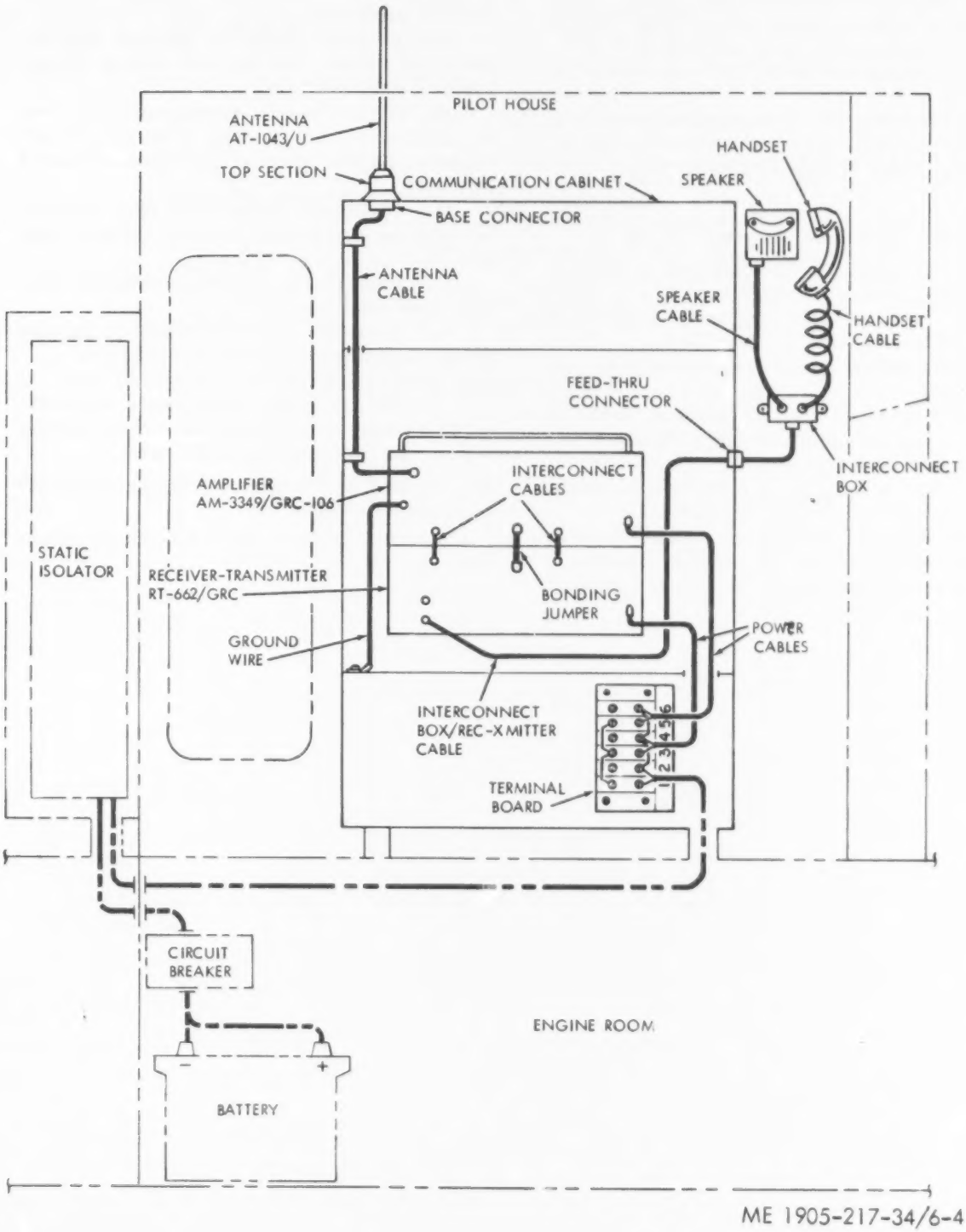


Figure 6-4. Radio set AN/GRC-106 (hulls 8540-8560 and 8580-8618).

CAUTION

Disconnect ground cable of battery assembly prior to removal of components.

(1) Remove communications cabinet front panel by unfastening thumbscrews.

(2) Disconnect antenna cable from amplifier connector and at the base of antenna. Remove nut, screw, spacer, wire cradle and clip. Remove and retain cable and supporting hardware.

(3) Remove antenna, top section and base. Retain antenna assembly.

(4) Disconnect the two interconnect cables and the bonding jumper from between amplifier and the receiver/transmitter. Remove and retain cables and jumper.

(5) Disconnect the two cables at amplifier connector and receiver/transmitter connector.

(6) Disconnect the two power cables at terminal block at base of communications cabinet. Remove and return cables.

NOTE

Record position of cable wires on studs or connectors to assure correct reinstallation of cables.

(7) Disconnect handset cable at the interconnect box. Remove the speaker unit, be removing attaching screws, nuts, and washers. Retain speaker and attaching hardware.

(8) Disconnect speaker cable at the interconnect box. Remove and retain handset.

(9) Disconnect cable from interconnect box to receiver/transmitter at the interconnect box. Remove the screws, nuts, and washers attaching interconnect box to bulkhead. Remove and retain box and attaching hardware.

(10) Disconnect cable from receiver/transmitter to interconnect box at the receiver/transmitter connector. Remove and retain cable.

(11) Disconnect ground wire and remove the amplifier AM-3349/GRC-106 from the mounting.

(12) Remove the receiver/transmitter RT-662/GRC from the shelf.

(13) Reinstall the communications cabinet from panel. Connect battery ground cable.

b. Repair. Refer to TM 11-5820-520-12.

c. Installation (*fig. 6-4*). Install components in reverse order of removal. Be certain that proper polarity is observed in connecting input cables.

Section II. NAVIGATION EQUIPMENT

-5. Remote Magnetic Heading System

Refer to TB 55-1905-217-34/1 for complete maintenance procedures for the RMHS. (All hulls have similar systems).

a. Removal. Refer to Figure 6-5 and proceed as follows:

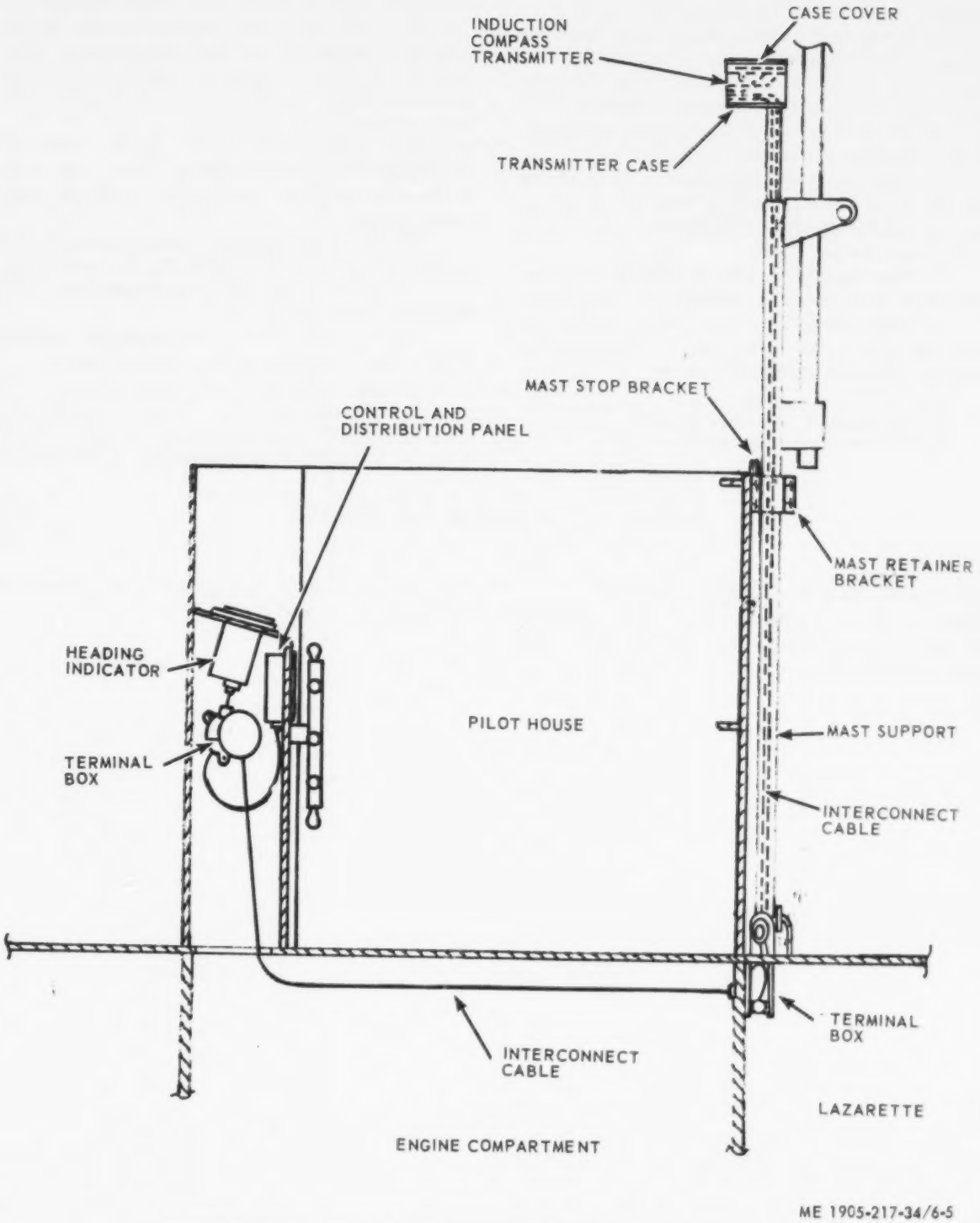


Figure 6-5. Remote magnetic heading system (hulls 8540-8560 and 8580-8618).

(1) Remove heading indicator by removing eight screws and washers from indicator protective cover, removing indicator protective cover, removing four screws and washers from indicator bezel, lifting indicator from panel, and disconnecting cable connector.

NOTE

Do not tamper with four calibrating screws on rear of indicator except during calibration.

(2) Remove induction compass transmitter by removing eight nonmagnetic screws and washers from case cover and three nonmagnetic screws and washers from transmitter, lifting transmitter from mounting surface, and disconnecting cable connector.

NOTE

Do not tamper with two screws securing transmitter indexing key to mounting surface, three external mounting nuts securing transmitter case to mast support, or three nuts and bolts securing mast stop bracket to mast retainer bracket.

(3) Remove interconnect cables by disconnecting wires from terminal box terminals and removing all tiedown straps securing cables.

NOTE

Record position of cable wires on terminals to ensure correct installation.

b. Installation. Install in reverse order of removal.

c. Calibration.

(1) Aline landing craft to 0° heading. Algebraically add heading of landing craft and reading of heading indicator. Record sum.

(2) Repeat step (1) for 90°, 180°, and 270° headings.

(3) Algebraically add sums from steps (1) and (2) and divide total by four. Record the quotient (index error).

(4) Aline landing craft to 0° heading and record heading of heading indicator.

(5) Remove all magnetic material from person who is to be adjusting transmitter case. Loosen three nuts securing transmitter case to mast support (fig. 2-6) and rotate transmitter case so that new heading on heading indicator is equal to heading recorded in step (4) minus the index error (magnitude and sign) calculated in step (3).

(6) Secure transmitter case with three mounting nuts, ensuring that position of transmitter does not change.

(7) Adjust N-S adjustment screw to obtain 0° reading on heading indicator.

(8) Aline landing craft to 90° heading and adjust E-W adjustment screw to obtain 90° reading on heading indicator.

(9) Aline landing craft to 180° heading and adjust N-S adjustment screw to remove one-half error of heading indicator reading.

(10) Aline landing craft to 270° heading and adjust E-W adjustment screw to remove one-half error of heading indicator reading.

(11) Repeat steps (7) thru (10) as required to optimize adjustment.

(12) Aline landing craft to 0° heading and adjust 0° adjustment screw at rear of heading indicator to obtain 0° reading on heading indicator.

(13) Aline landing craft to 180° heading and adjust 0° adjustment screw to remove one-half error of heading indicator reading.

(14) Aline landing craft to 45° heading and adjust 45° adjustment at rear of heading indicator to obtain 45° reading on heading indicator.

(15) Aline landing craft to 225° heading and adjust 45° adjustment screw to remove one-half error of heading indicator reading.

(16) Repeat steps (12) thru (15) as required to optimize adjustment.

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APPENDIX A

REFERENCES

A-1. Fire Protection	
TB 5-4200-200-10	Hand Portable Fire Extinguishers Approved for Army Users.
A-2. Lubrication	
LO 55-1905-217-12	Lubrication Order, LCM 8 (All models)
LO 55-1905-217-12/1	Lubrication Order, LCM 8 (Hull Nos. 8500 thru 8519).
LO 55-1905-217-12/2	Lubrication Order, LCM 8 (Hull Nos. 8520 thru 8539, 8540 thru 8560, and 8580 thru 8618)
LO 55-1905-217-12/3	Lubrication Order, Engine
A-3. Painting	
TB 746-93-4	Painting of Vessels
TM 9-213	Painting Instructions for Field Use
A-4. Radio Suppression	
TM 11-483	Radio Interference Suppression
A-5. Maintenance	
TB 55-1905-217-34/1	Remote Magnetic Heading System (RMHS) Vessel Design. LCM 8 MOD 1.
TB 750-651	Use of Antifreeze Solution & Cleaning Compounds in Engine Cooling System
TM 38-750	Army Equipment Procedures
TM 55-1905-217-12	Operator and Organizational Maintenance Manual-LCM(8)
TM 9-6140-200-15	Operation and Organizational Field and Depot Maintenance Storage Batteries, Lead Acid Type
TM 5-4920-200-15	Operator, Organizational, Field and Depot Maintenance Manual, Engine Analyzer, Gas Turbine
TM 11-5820-399-35	Field and Depot Maintenance Manual, Receiver-Transmitter RT-246-VRC and RT-524/VRC
TM 11-5820-409-35	Field and Depot Maintenance Manual, Receiver, Radio R-442/VRC
TM 11-5820-520-35	Field and Depot Maintenance Manual, Radio Set AN/GRC-106
TM 11-5820-689-15	Field and Depot Maintenance Manual, Radio Set AN/SRC-32
TM 55-1905-217-20P	Organizational Maintenance Repair Parts and Special Tool List
TM 55-1905-217-34P	Direct Support and General Support Maintenance Repair Parts and Special Tools List
TM 11-5820-401-10	Operators Manual, Radio Sets AN/VRC-46 and -47
TM 11-5820-520-12	Operator and Organizational Manual, Radio Set AN/GRC-106
A-6. Shipment and Storage	
TB 740-97-2	Preservation of USAMEC Mechanical Equipment for Shipment and Storage
TM 740-93-3	Administrative Storage of Equipment
TB 740-93-4	Preservation of Vessels for Storage
A-7. Destruction of Equipment	
TM 750-244-3	Procedures for Destruction of Equipment to Prevent Enemy Use

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By Order of the Secretary of the Army:

FREDERICK C. WEYAND
General, United States Army,
Chief of Staff.

Official:
VERNE L. BOWERS
Major General, United States Army,
The Adjutant General.

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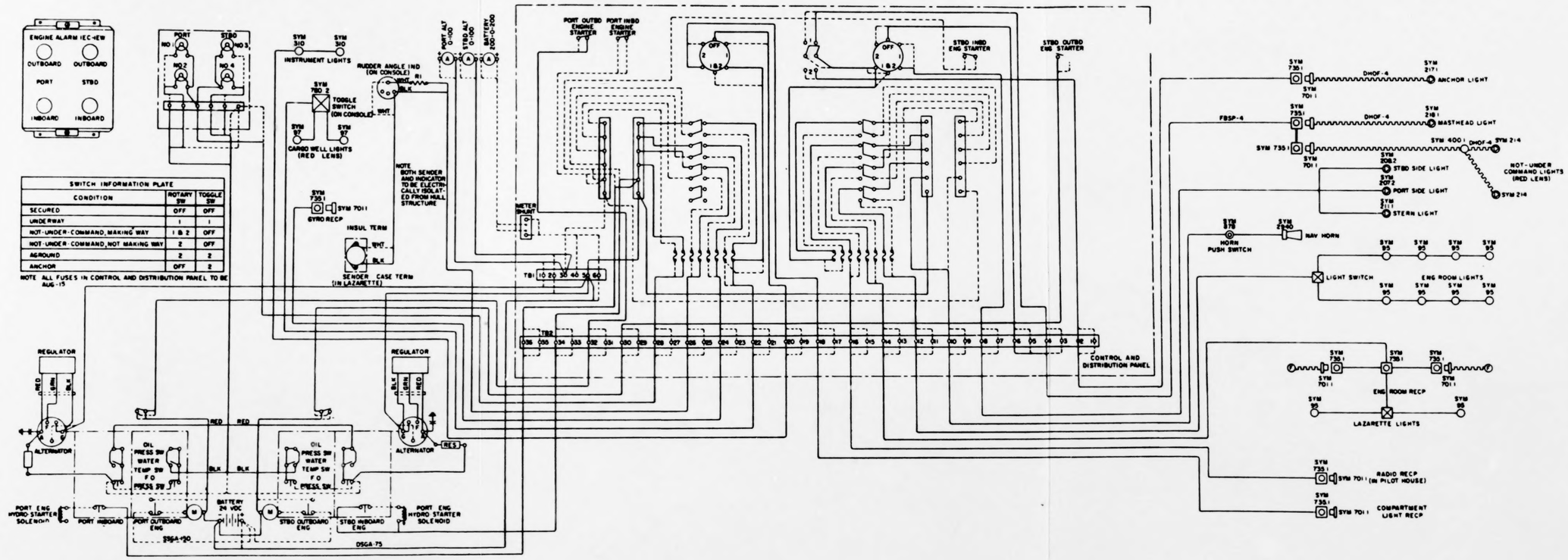

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Figure 1-2. Wiring diagram—hull no. 8500 thru 8519.

Figure 1-2

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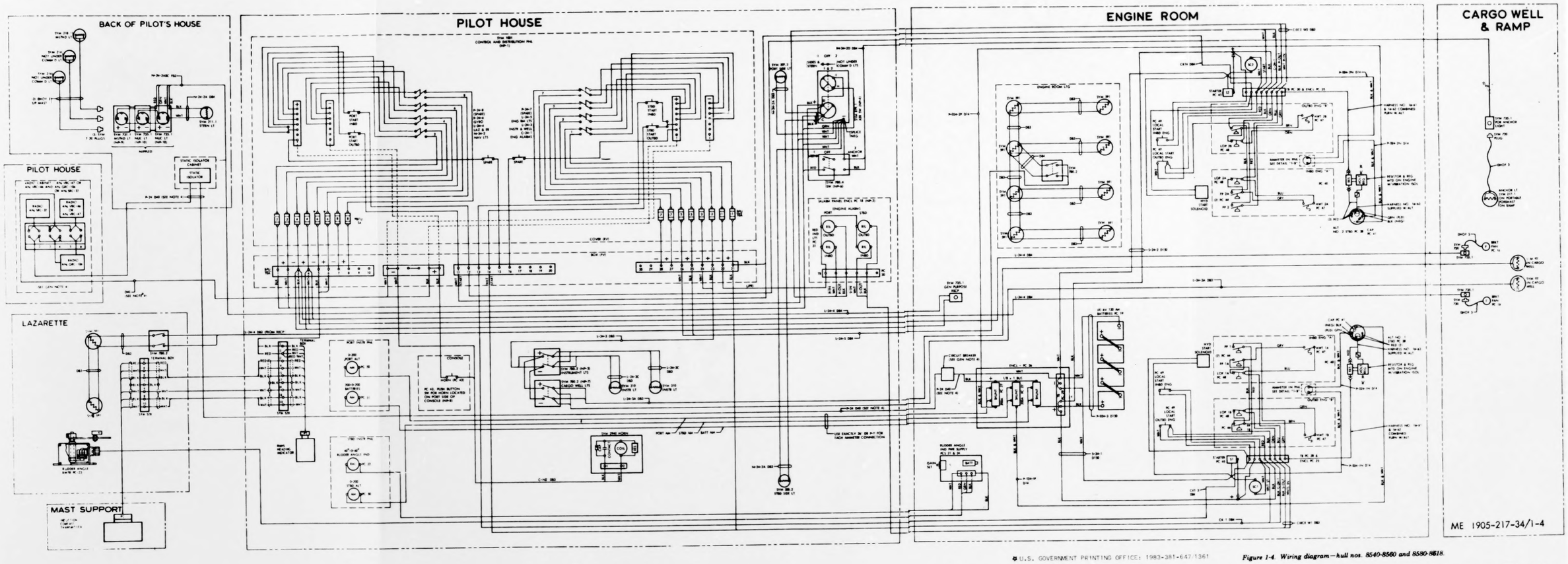

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Figure 1-4. Wiring diagram—hull nos. 8540-8560 and 8580-8618.

Figure 1-4

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